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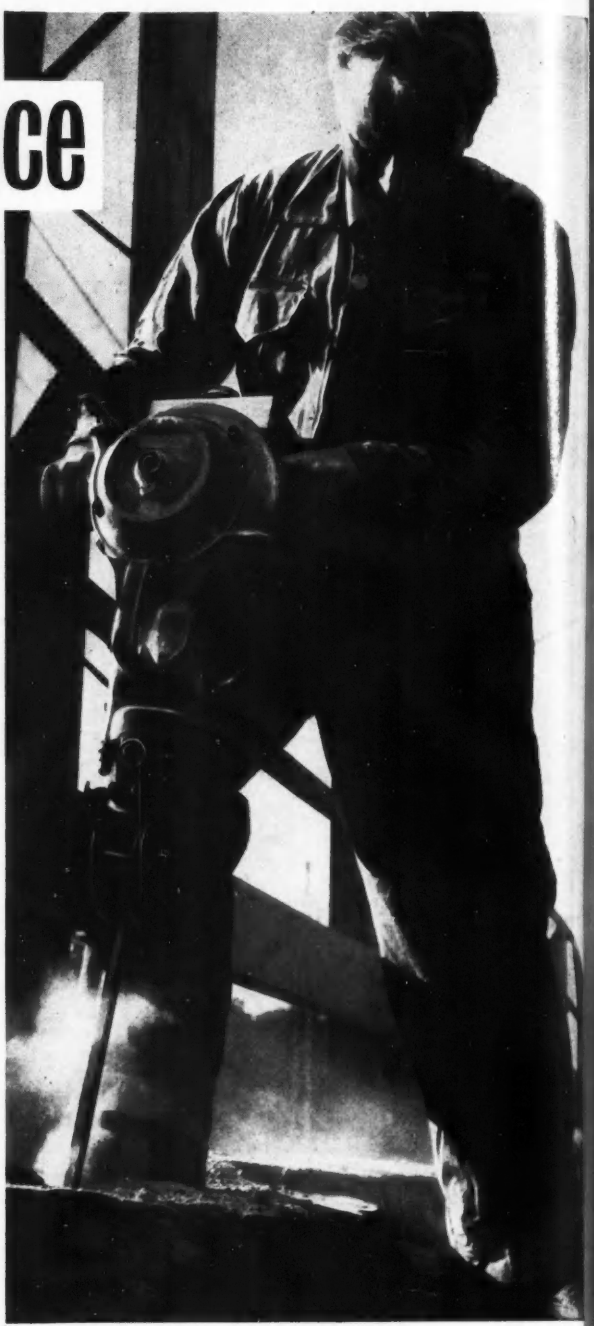

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THE ENGINEER

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SIXTEEN ART PLATES

RETROSPECT

Three months ago we were in despair ! Soon a New Year would be upon us and we should be called upon to write about and to comment upon the happenings of 1956. But in its beginnings and throughout the whole of its course until the autumn there was nothing impressive about the events of the year. There were no announcements, such as those which made the early months of 1955 exciting, about plans for developing nuclear power or modernising the railways ; and even the economic situation, a discussion of which has so often got this editor out of a difficulty, was quite undistinguished ; it was not very good during the first nine months of 1956 ; but it was not really bad either ! Of course, progress continued in every engineering field. Other articles in this issue record it. But though technically of deep interest, it was all pretty humdrum and to be expected. There was little that was dramatic and only an event here or there sufficient to startle the imagination into activity.

CALDER HALL

Then suddenly in the last three months things began to happen. In the history books, we suppose, it will be events in Egypt that will be given pride of place. The chain of cause and effect will be recorded with care ; the building up in Egypt of Russian arms, the cancellation of promised aid for the building of a new Aswan dam, the nationalisation of the Suez Canal, Anglo-French transference of forces to the Mediterranean, an explosion into war between Israel and Egypt, Anglo-French intervention, the blocking of the Canal and the blowing-up of one of the only two active oil pipelines by the Syrians. But we beg leave to suggest that the historians, if they concentrate on Middle-Eastern events, will have placed emphasis in the wrong place. Far more significant for human history-to-be was a short ceremony that took place in Cumberland on a breezy but sunlit October afternoon. The opening by the Queen of Calder Hall nuclear power station presaged an extraordinary advance in mans' control of his environment and an end eventually to his fears that through the using up of fossil fuel deposits civilisation might be brought to a finish. The event was unexampled. For pioneering achievements in the past, with which Calder Hall station can be compared, such as the erection of Newcomen's first engine and the first transmission of power electrically, both of which led to revolutions in human ways of life, went almost unrecognised for what they were. But on that October day the Queen and all who were privileged to see and hear her were well aware that they were assisting at an epoch-making ceremony. For though no man can yet say how much nuclear power can do for the human race, all men can see how great are its potentialities.

Calder Hall station is only a beginning. Its economics are uncertain ; for the price at which it will generate power for public consumption depends on the price of its by-product plutonium, which only the Government can fix. Its design is based partly on inspired guesswork, biassed heavily towards safety. Already it is known to be unnecessarily conservative. Calder Hall station was conceived as a great full-scale experiment in the generation of nuclear power. Yet already, though much has still to be learned about operation and maintenance, it has become a prototype for a family of similar though more advanced stations the contracts for the construction of which were announced by the Central Electricity Authority and the South of Scotland Electricity Board just before Christmas. Nor, it can be stated with more confidence now, is Calder Hall, as some feared whilst it was still under erection, already obsolescent in type. Other kinds of reactor may be able to compete in the future. Other types of reactor may be preferable for tasks of a different nature. But the standards of the gas-cooled graphite moderated reactor will be those by which their performance will be judged and there is far more room for modification and improvement of performance than was at one time thought possible. Moreover, the successful completion of Calder Hall has effected something else. Now that industrial firms are concerned with design the veils of secrecy are coming down. Soon engineers will be as familiar with what goes on in a reactor as they are with steam generation in a boiler.

EUROPEAN CUSTOMS UNION

But if the opening of Calder Hall power station overshadowed every other event of 1956 in technical importance, there was at least one other happening which may prove eventually to have comparably beneficial consequences. Throughout the year—unnoticed in Britain save by a few economists and those having special interests on the Continent—Germany, France, Italy and the " Benelux " group of Belgium, Luxembourg and the Netherlands were engaged in negotiating a treaty, yet to be signed, which would create a customs union amongst those nations and remove all barriers to trade amongst them. Late in 1956 the Chancellor of the Exchequer posed the question to this country—could Britain stand wholly aside ? True, barely a quarter of Britain's trade is conducted with European countries. That was the reason why, when the European Coal and Steel Community was set up quite soon after the war, the British coal and steel industries did not join it. But could this country afford to stand aside as a relatively small economic unit outside a customs wall protecting a common market of 150 to 200 million people ?

The Chancellor was in no hurry for a decisive answer. He asked industry and the T.U.C. to pronounce only upon the question whether this country should enter upon negotiations with the countries concerned to see in what way Britain's economy could advantageously be linked with the common market. His proposal was that the negotiations should envisage the creation as between Continental Europe and Britain of a " free trade area " for all commodities except food, drink and tobacco. About half of Great Britain's trade is conducted with the Commonwealth and some 90 per cent of Commonwealth exports to the U.K. come under the headings of food, drink and tobacco. Thus the retention by this

country of duties upon those commodities would permit preference to be given to Commonwealth products in return for the corresponding preferences Commonwealth countries offer to U.K. manufactures. Both industry and the T.U.C. complained that the Chancellor had given them too little time adequately to study the problems involved, overlooking, perhaps, that he had never asked them to do so but only to signify approval or disapproval in principle of the opening of negotiations. But, in fact, of course, no pronouncement upon the principle could really have any value unless some study was made of the nature of the problem with which the negotiations would be concerned. In the event, though hesitantly on the part of several trade associations, the Government was given a green light to enter upon negotiations.

A source of satisfaction to all those who, like ourselves, feel that the U.K. cannot afford not to be associated in some way with a European customs union was the manner in which the Government was encouraged to enter upon negotiations. Industry and the T.U.C., alike, stressed the need to provide "safeguards" if a free trade area were established. But upon examination the "safeguards" turned out to be not proposals for the retention of duties upon this kind of product or that—a multiplicity of pleas for such exceptions would be destructive of the whole conception—but wise suggestions for the removal of barriers to trade, other than duties, which might unduly favour one nation as against another. More will unquestionably be heard about the proposition during this New Year and it is a good augury for a successful development of the situation that no matter of substance about it divides the political parties. For it will take very many months to negotiate a treaty and ten or fifteen years for it to become fully effective. An intrusion of party politics into the affair would be ruinous. Should the customs union and the free trade area come into being the first step may have been taken towards the creation of a federation of European States. But that is to look too far ahead. The more immediate task for Britain's engineering industries will be to study how best to profit from the gradual creation of a common market of some 200 or 250 million people. Scope is clearly offered for the development of automation techniques.

Clean Air

Early in October the Queen gave her assent to an Act that will have repercussions on the activities of many engineers and which may well have eventually quite profound effects upon the English scene. The Clean Air Act does not completely satisfy the aspirations of the National Smoke Abatement Society. But it goes a long way towards doing so. Nor, of course, can it rid the air over Britain of smoke overnight. A long period of striving after smokeless air still lies ahead. What it does do is to put power behind the elbows of those who have long preached the harm done by polluted air, and, even more, it frees the hands of that very large class of people favourably disposed towards the prevention of smoke, but unwilling to exert themselves unless everyone else does so, too. Our sympathy is with them. For what good has it done the owner of a factory in the past—or anyone else—to insist that his chimney must never smoke when hundreds around it have been smoking merrily? But the point does need preaching and will continue to need preaching that the issue as to whether the country gets clean air or not now lies in the hands of the people themselves. The powers are there for local authorities to use. But it is for the public in general to insist that they are used. Additionally, there is a need to preach to the public that industrial chimneys are neither the sole nor even the major source of smoke pollution; domestic chimneys produce at least half the smoke. For without such preaching it may prove difficult to set up the "smoke control areas" and "smokeless zones" envisaged under the Act, and there may be too little incentive towards the rapid expansion of the supplies of smokeless fuels for domestic grates.

Ridding the air of smoke is, however, only a part, and possibly the lesser part, of preventing air pollution. Its benefits are obvious. Sunlight becomes unrestricted, buildings, paintwork, fabrics and human flesh will remain clean and fresh far longer, plants will the better flourish, and fogs when they occur will be white instead of yellow or black. Danger to health will diminish. But the elimination of smoke can only alleviate—it cannot prevent—that steady and very costly corrosion and deterioration of stonework and metalwork that goes on in every urban and industrial area and over the countryside to leeward of industrial areas. Even when chimneys emit smoke no longer, sulphur dioxide will continue to pour forth. Here the offence of the domestic chimney is no longer rank. Industrial furnaces, power station chimneys, steam locomotives and motor vehicles are the chief offenders, and how to prevent its emission is a problem still awaiting solution. Gas washing, though technically satisfactory, is an expensive expedient and is applicable with any suggestion of economy only to very large flows of gas, and the elimination of sulphur from solid and liquid fuels has not yet proved practicable. Much research needs to be done if the sulphur is to be trapped before it reaches the atmosphere, especially if it is desired to recover it in usable form for the production, for example, of sulphuric acid.

Water Supply

Strangely, for there is an analogous relationship between clean air and clean water, the subject of water pollution attracted very little attention during 1956. It was left to a relatively very small association of anglers actively to take up the cudgels on behalf of all those whose interest lies in the maintenance of clean water in the country's rivers, although much good work gaining less publicity was done by River Boards. Yet year by year the difficulty of maintaining adequate water supplies for Britain's major cities grows and not a little of the difficulty can be traced to the pollution of rivers that might otherwise prove suitable sources of supply. Nor can the abstraction of water from streams and underground sources be viewed without some feeling of disquiet, since by depleting flows it not only affects directly riverside amenities, the watering of farm stocks, fishing interests, and recreational pursuits, but also makes the waters less tolerant of the sewage and other effluents that are poured into them, and so contributes to pollution. Suggestions were made during the year that water abstractions should be made not near the sources of rivers, but close to their mouths. They came, it is true, principally from the angling fraternity which is now as much alarmed by water abstraction as by pollution. But the idea, if indeed only of limited applicability, is still one deserving of technical consideration.

Education

During the year the Government's plans for the encouragement of scientific and technological education became progressively clearer. A complete and logical plan emerged. At the top of the pyramid the universities are to be expanded at a rate which will provide some 60 per cent more places for students of science and technology within about five years. To provide accommodation the Government is to authorise the start of building projects up to a value of £10,400,000 this year, £12,000,000 in 1958 and £12,000,000 again in 1959, over and above the total of some £15,000,000 to be spent upon the expansion of the Imperial College of Science and Technology in London. These figures compare with an average rate of expenditure of only £1,000,000 per year since university expansion began after the war. Next come the colleges of advanced technology of which five were appointed in 1956. Others will follow. These colleges will henceforth concentrate upon the provision of high-level courses leading to the new award of Dip. Tech., which is apparently to be of honours degree standard, but of a kind which, besides inculcating the fundamentals of science

and technology, will be weighted quite heavily towards their application to development and design. Lower down the pyramid, but no less useful, are regional, area, and local colleges, providing a variety of courses, full time, sandwich and part time up to National Certificate standards. The number of students taking advanced courses is to be increased by 50 per cent and the number released on part time is to be doubled.

In isolation these plans sound admirable. But in the light of two other factors they appear less liberal. The first of these factors is that owing to a high post-war birth-rate the number of eighteen-year-olds in the country will increase from some 640,000 now to 850,000 in 1965, so that an increase of 60 per cent in university places for those studying science or technology and of 50 per cent in advanced courses available amounts to a provision for only a small increase in the proportion of youngsters educated to high standards. The other factor is that by comparison with the efforts being made by other nations Britain's seems less significant. At present we train only about 7000 engineering students to graduate standards per year, whereas the Russian figure for a population only four or five times as big is 80,000. Yet it is in fact difficult to see how the Government could dare to move faster. The trouble arises not from the expense of providing places in universities and colleges for the training of technologists—there seems no lack of willingness upon the part of the Government to assist financially—but from the difficulty of persuading boys to take up technology as a career.

Yet how paradoxical it is that it should be so! For among the blessings that engineers are continuing to confer upon mankind is that of recreation of a demand in increasing quantities for men of brain rather than brawn. Only a bare two centuries ago the bulk of mankind had to toil that a chosen few might have leisure enough to cultivate their brains. For most men (and women, too) brawn was more important than brain. It is engineers who have wrought the change. Man is becoming the machine maker, the machine minder, and the machine maintainer. For these tasks demands are increasingly made upon his intelligence. That, of course, is why every developed nation in the world is now striving to raise the educational level of its peoples. Yet quite apart from the rather astonishing fact that whole populations are showing an ability to absorb education, it is equally astonishing that mankind is failing to appreciate at all fully whence this incessant demand for educated intelligence derives its impetus. Significantly, the demand comes from the technologies, of which engineering is the chief. It is engineers who predominantly are conferring upon mankind a kind of society in which all men, and not only the few, need to use their brains if they are to prosper. We cannot but believe that it is good for the human race that it should be so.

Yet this very profession which is, more urgently than any other, calling out for more and more men of highly educated intelligence, this profession that has been and is creating conditions that encourage men to educate themselves is, in Britain at least, rather lowly regarded. When, for example, the Lords discuss technological education, some among their number always feel a need to stress that engineering is a respectable profession! Parents and schoolmasters know so little about the work that engineers do that many of them discourage brighter boys from taking up a technology, preferring to suggest the arts or pure science. More fully in 1956 than in 1955, engineers came to a realisation that if the insatiable and growing demand within industry for men educated to high technological standards was to be met, schoolmasters and boys at school must be better informed. Industrial firms began to take a greater interest in schools, endowing scholarships or making gifts of equipment, and Institutions organised conferences for headmasters and lectures for boys and actively studied what else could be done. There is a long haul here. But if Britain is to maintain its place as a great industrial and engineering nation the status of engineers in the eyes of its inhabitants must and will have to be raised.

The Oil Situation

As 1956 ended, industry and transport were suffering from a shortage of oil, a direct consequence of the blocking of the Suez Canal and the blowing up of an oil pipeline in Syria. Naturally confidence in the continuity of supplies of oil from the Middle East was shaken; and there was some questioning as to whether the country should attempt to reduce its dependence upon oil fuels. As soon, however, as the situation is critically examined, it is seen that no alternative exists. There is no hope in coal. Under the Coal Plan of 1949 the output of coal was to be raised eventually to 240 million tons a year. Experience since then has indicated that even that figure, strongly criticised at the time as too low to meet national needs, is beyond the power of the N.C.B. to obtain, and in its report for 1955 the Board whittled it down to 230 million tons a year to be reached some time in the next decade. It is dubious whether even that output will ever be reached. The only other practicable alternative is the generation of much more nuclear power than is at present envisaged. But in that field it would be rash to try to travel too fast. Experience needs to be gained at Calder Hall before any attempt is made to bring about a wholesale change-over from the building of conventional power stations. Furthermore, neither additional supplies of coal nor additional supplies of electricity could help to keep road transport moving. There liquid fuel is essential. In fact, the situation is that without substantial supplies of oil this country's and Europe's prosperity would vanish. We cannot do without it, and in our view the country is likely in the future to become more, not less, dependent upon it. Nor do we think the situation peculiarly alarming. For the Middle Eastern producers of the oil are just as dependent for their prosperity upon selling the oil as Europe is upon its use as a fuel. The difficulty is temporary, even though the Middle Eastern political situation may prove troublesome for years to come.

Three Other Events

Three other events of the year which deserve notice here all relate to its last few months. In September some details became available of the artificial satellites whose manufacture was being begun in the United States and which it is hoped to set orbiting around the earth within a few months' time as a contribution to the Geophysical Year. They will be thin-walled magnesium spheres about 20in in diameter containing scientific equipment, and each will be lifted to a height of about 300 miles and accelerated to a speed of 25,000ft per second by a three-stage rocket. How little power there is to spare to achieve this purpose is revealed by the figure that at a weight of 20 lb each satellite will account for only about one-thousandth of the weight of the complete rocket. There is clearly a long way to go yet before a manned satellite circles the earth! But if the experiment proves a success a first step towards it will have been taken.

The other events were earthbound. Late in October the Government and the British Transport Commission announced a plan whereby deficits incurred in operating British Railways, until such time as the modernisation that was being pressed forward with vigour during 1956 has made them profitable, will be met by borrowing from the Consolidated Fund up to a maximum of £250 million. Neither the Government nor the Commission favoured any form of subsidy, on the ground that it would be an admission of defeat if one were granted, and the morale of the railways would be adversely affected. But whether in fact the railways can be made to compete effectively with road transport, even when fully modernised, only the future will reveal. Still later in the year the Government fully revealed what its intentions are towards the Central Electricity Authority. By the

terms of a Bill published in December the Authority will be abolished ; Area Boards, together with a new Generation Board, will become autonomous and a new Electricity Council will be set up, upon which all the boards will be represented. It will act as a co-ordinating body, to raise finance, and to act as the agent of the boards for the performance of services best carried out in common. The intention is clearly to introduce decentralisation analogous to that already imposed on the railways. The new organisation will undoubtedly be workable ; whether it will, on balance, turn out to be an improvement is another matter.

Conclusion

How odd it seems at a first thought that a Retrospect such as this should have so much to say about the future. There is hardly a paragraph in it that does not look forward rather than back. Yet is it really so odd ? The past is dead, immutable ; the present passes in a flash ; it is only to the slow approach of the future that we can look with unflagging hope. All we do and say—unless, indeed, we indulge in the unremunerative pastime of recrimination—is done and said with an eye to its future consequences. It is true, of course, that those consequences are seldom fully foreseen. We act with beneficent intentions—at least, most of us do. But often Fate steps in, unkindly, to give the affair an unexpected twist so that we find ourselves in the end no better off than we were before. Yet even so, there is Stevenson's immortal philosophy to support us ; it is a better thing to travel hopefully than to arrive !

That philosophy it might seem does not apply to engineers. For in engineering there are ends, attainable ends. A concept is formed for a nuclear power station, for an artificial satellite, for some new invention or for some improvement of an old one. In due course it is likely to become a reality. That is an end achieved, so far as engineers are concerned, even if its attainment leads on, as it usually does, to a concept of something better. But in so far as the world is concerned it is not an end, but a beginning. We engineers make great material gifts to the world; and it is certainly more blessed to give than to receive. For to the recipient falls the responsibility of making a wise use of the gifts. Probably because too few engineers interest themselves in the world's administration, the gifts go sometimes unappreciated. In anger a naughty child sometimes flings a costly toy to lie broken on the floor rather than share it with another. It was pitiful to engineers in 1956 to see grown men, heads of States, so behaving, crying as they blocked a canal and blew up a pipeline, " If I can't have it, then you shan't, either ! " God grant the world more sense in 1957 !

A Seven Day Journal

Electrification Extension to Southend-on-Sea (Victoria)

On Monday last, December 31, through electric train services between Southend-on-Sea (Victoria) and Liverpool Street were inaugurated. With this extension of electrification and that to Chelmsford completed earlier in the year, more than 30 route-miles have been added to the electrified lines of the Eastern Region, and the £2,500,000 electrification scheme for the Shenfield–Southend (Victoria)–Chelmsford lines has been completed. At present the whole of this electrified system operates on 1500V d.c., but provision has been made for its conversion at a later date to the 25kV a.c. system to be adopted on British Railways. In the new services 119 trains are provided on the line from Mondays to Fridays as compared with the previous sixty-four steam trains, and in the morning and evening peak hours there is now seating accommodation for over 18,000 passengers as compared with about 12,000 previously. To provide for the new services thirty-one four-coach, multiple-unit train sets have been built. Each multiple-unit comprises a driving trailer coach, a motor coach, a trailer coach and a second driving trailer coach.

The Engineer
100 Years Ago
(JANUARY 2, 1857)

" Pickings from the Past "

" In reviewing the mechanical and other inventions of the past year, we are more struck with the idea of quantity than quality. The usual round 3000 patents have been worked off, and the Thames has not been ignited except in one place, and that by Mr. Bessemer. The flame thus produced burnt very brightly, but, bright as it was, it appears to have had sufficient cold water thrown upon it to dim its radiance, although we have reason for believing it is not yet *quite* put out. . . .

" A discovery, for which the past year may claim the merit, is the easy production of the new metal aluminium. It is suited to all the purposes to which silver is now applied, and will, probably, at some future day become literally cheap as dirt. . . . We may next notice, as the work of 1856, the final completion of arrangements for laying the great Atlantic cable. The practical solution of the problem as to whether a cable could be laid of so great a length at anything like a reasonable cost, was solved by the very able experiments of our friend Dr. Whitehouse, who proved that the law known as the ' law of squares ' was no law at all, as regards electric currents. . . .

" The next thing for which the year 1856 will be proudly looked back upon is the termination of the great struggle with the great Russian Bear, which ended, if not in his complete overthrow, at least in his being obliged to sing very small. He is still said to be compelled to wear a great quantity of flannel about the jaws from an attack of tic-dolouroux, which he has had ever since. The war is said to have ended from the Bear getting frightened, which brought on a complaint for which Dr. Jacobi recommended prepared oyster shells. This may appear to be more of a medico-political question than an engineering one, but those who know anything about patents will know also the fearful havoc which the peace made with revolving fire-arms, cannons, explosive compounds, and the like. Indeed, it may be said to have sewed up the patentees' minds in these directions, and ' not proceeded withs ' were found to tumble in very freely after its proclamation."

National Boat Show

On Tuesday, January 1, the third National Boat Show, which is sponsored by the *Daily Express* and organised by the Ship and Boat Builders' National Federation, was opened at Olympia, London, by Lord Hailsham, the First Lord of the Admiralty. This year's show, which will remain open until January 12, continues the increase in size noted in the 1956 show, and more than 200 exhibitors display the varied products of the boat-building industry. Among the exhibits are a large number of small craft, ranging from a 5ft coracle to a 46ft lifeboat, and including sailing and rowing dinghies, runabouts, motor boats and other powered boats, cruisers and yachts, together with examples of the equipment essential for sailing, cruising and water sport generally. Among the craft of special interest on view are : the turbo-jet hydroplane " Bluebird," the world record speed holder, the hydroplane " Miss Windermere III," also holder of a world speed record, the 18ft catamaran " Endeavour," which is the fastest sailing craft, and the home-made 26ft yawl " Orenda," which recently completed a fifty-six-day crossing of the Atlantic. There is also an amphibious caravan which can be launched from the river bank or trailed behind a car. As in previous years, there is a " build-it-yourself " boatyard where different craft can be seen under construction and glass fibre techniques are demonstrated, and also a section which is concerned with solving the problem of " boating on a budget." Petrol and diesel power units on show number more than a hundred.

Nuclear Propulsion of Merchant Ships

The Atomic Energy Research Establishment, in collaboration with the British Shipbuilding Research Association, has held a conference at Harwell to acquaint shipowners and shipbuilders with the present position regarding the possibilities of applying nuclear energy to the propulsion of merchant ships. Forty-nine shipowners and fifty-eight shipbuilders attended the conference, along with representatives from a number of Government departments. In opening the conference Sir John Cockcroft emphasised that the technical feasibility of nuclear propulsion for marine purposes had been demonstrated by the performance of the U.S. submarine " Nautilus," which had a pressurised water reactor, but he drew attention to the large gap in costs which must be bridged before nuclear propulsion became commercially attractive. Sir John referred to some possible developments including the reduction of fuel costs by the use of plutonium produced by land-based nuclear power stations. It was reported to the conference that the B.S.R.A. team at Harwell was collaborating with the Authority in the development of possible reactors, such as the organic liquid moderated system and systems based on the use of natural uranium, whilst at the same time pursuing the marine feasibility study for which it was originally appointed. The object of this separate study would be to examine the problems associated with the design and manufacture of a unit for a ship and to produce a schematic design, including the turbine aspect.

Nuclear Power in 1956

DEVELOPMENTS in the nuclear energy field during 1956 were dominated by the opening of Calder Hall. The events, leading up to, and culminating in, the official opening of this, the world's first nuclear power station, on October 17, by Her Majesty the Queen, were a triumph for Britain's scientists, engineers and technicians. It was a welcome reminder to ourselves, as well as the world at large, that this country can still show leadership in new technologies, and can do this with a sureness of technical judgment that made possible an astonishingly rapid advance from scientific study to the completion of construction of a major industrial plant. Undoubtedly, just as 1955 will be remembered for the Geneva Conference on the Peaceful Uses of Atomic Energy in the calendar of nuclear power progress, so 1956 will be the year of Calder Hall. Yet much happened in addition to this and before commenting further on Calder and where we go from there it is as well to look back at some of the other achievements of the year.

New Reactors

In January, 1956, the Atomic Energy Authority announced that two new reactors were in operation at Harwell. These were ZEUS (Zero Energy Uranium System) and ZETR (Zero Energy Thermal Reactor). Later in the year LIDO (a swimming pool reactor) started working at Harwell, and in October it was announced that DIDO, Britain's first large heavy water reactor, had been completed also at Harwell, and had gone critical. These four reactors, all of them research tools, are very different from each other. Their differences are to some extent reflections of the diversity of the reactor research programme, and perhaps to a greater degree a measure of the breadth of research which is essential for successful reactor development.

ZEUS is an experimental system strictly related to one particular reactor core. It is, in fact, a model of the core arrangement of the Dounreay fast reactor. The core of ZEUS is a cylinder approximately 20in in diameter and 20in long, made up of uranium highly enriched in the fissile isotope U^{235}. This core is surrounded by a blanket consisting of many tons of uranium. Much basic nuclear physics information on fast fission systems had already been obtained from ZEPHYR, Harwell's other zero energy fast reactor, and such data was essential in designing the Dounreay core. But, however accurate this data is, there remain many uncertainties as to how such a reactor core will behave in practice. Calculations, even using machines, have as their starting point somewhat simplified models of the actual core. It is evident that one reason for building ZEUS was to check the amount of fissile material that would be required to make the core go critical. The amount of U^{235} needed was apparently very close to the value that had been predicted. No doubt ZEUS will also provide much useful information to the designers of Dounreay on such matters as the effectiveness of the control rods. As the reactor only operates at 100W (*c.f.*, Dounreay's design power rating of 60MW) there is little residual activity in the system when it is shut down, and so changes to the core, such as altering the position of fissile material can readily be made. This, of course, is also aided by the fact that no circulating coolant is required for operation at such a low power.

ZETR has a more general purpose. It uses a nuclear fuel in solution and has been built to supply data on the quantities of such fuels that will be required for large-scale reactors of this type. When first started up light water was being used as the solvent, but it was intended to change over to heavy water during the year.

LIDO and DIDO, unlike ZEUS and ZETR, are essentially sources of neutrons. LIDO is a swimming pool reactor, intended primarily for shielding studies. It utilises fuel elements of the enriched uranium flat plate type, and the core assembly is suspended in a tank of purified water from a trolley which can be moved along or across the top of the tank. Thus the core can be moved to any desired position in the tank. The latter, which is 8ft wide, 28ft long and 24ft deep, is constructed generally of concrete, but with a number of aluminium " windows " set into the walls at various positions. Shielding materials it is intended to test can be built up as a wall against one of these windows and the core then moved across towards it. The effectiveness of materials for biological shielding can then be measured directly. If liquids or solutions are to be tested, then obviously tanks of the solutions concerned can be placed against the " windows." The reactor has a peak neutron flux of 10^{12} thermal neutrons per square centimetre per second and a maximum power output of 100kW. The Atomic Energy Authority has stated that one of the major tasks with which work on this reactor will at first be connected is in the development of the British submarine propulsion unit.

DIDO is a much more powerful unit altogether ; in fact, it is the most powerful experimental reactor in Western Europe. Heavy water is the moderator and the fuel enriched uranium. At full power the reactor will develop 10MW of heat and its neutron flux will be 10^{14} neutrons per square centimetre per second. DIDO is an extremely important addition to the nuclear research facilities in this country. Probably some of the most difficult problems that the reactor designer and the metallurgist have to solve when considering any design of reactor are those concerned with the behaviour of materials under irradiation. Innumerable experiments may have to be made in a laboratory—for example, on the rates of corrosion of a particular structural material with a given coolant. Yet, no matter how good the results of such experiments may look, until it has been proved conclusively that these results are not altered under conditions of irradiation, they are useless other than as a hopeful indication of what might happen. As the degree of exposure to irradiation is usually only one variable among many, it is frequently necessary to conduct a whole programme of in-pile experiments, and it can be appreciated that this is usually an extremely lengthy business. The effects of irradiation are usually cumulative, and so shorter tests can be carried out in higher neutron fluxes. As Sir John Cockcroft pointed out on November 21, when DIDO was officially opened by Sir Cyril Hinshelwood, Harwell would now have available for research purposes a neutron intensity forty times higher than they had had previously, and tests on components of the nuclear power stations of the future would be reduced from years to weeks. This fact is of enormous importance when considering the rate of future developments in the nuclear power programme. The reactor has not only pockets into which specimens can be inserted, but also a number of holes which will take loops. In these loops fluids can be circulated over materials or specimen fuel elements to obtain information on the behaviour of these specimens under irradiation with dynamic cooling conditions. The reactor is also a powerful neutron source for nuclear physics studies, and it will, in addition, be used for the production of cobalt 60 of high specific activity. The reactor and its associated plant and buildings was designed and constructed by the U.K. Atomic Energy Research Establishment, in association with the Ministry of Works and Head Wrightson Processes, Ltd.

Two other research reactors are being built, similar in many respects to DIDO. One of these is PLUTO, which can be seen going up at Harwell on the site already containing DIDO and LIDO. The second, which is a duplicate of PLUTO, is being built at Dounreay. These reactors are also heavy water moderated with a peak thermal neutron flux of 10^{14} neutrons per square centimetre. They are designed, however, to have more extensive facilities for loop work than DIDO possesses.

Construction of the fast reactor at Dounreay has continued throughout the year. The top half of the containing sphere has been completed except for the crown plate, which has been left off to allow plant to be lifted in, and work is passing from the civil and structural phase to that of mechanical and electrical plant installation. At Calder Hall the second half of the Calder " A " station has been completed and work on Calder " B " is proceeding steadily. At Chapel Cross, in Annan, work on the two units, which is being supervised for the U.K.A.E.A. by Messrs. Merz and McLellan, is also understood to be on programme. These units are copies of those at Calder.

All the reactors referred to above are ones being built on sites owned and operated by the Atomic Energy Authority. The Associated Electrical Industries, John Thompson group of companies are, however, building a research reactor at the A.E.I. Research Laboratories at Aldermaston Court. This will be a light-water-cooled, light-water-moderated reactor of a modified swimming pool design. The U.K.A.E.A. has also asked the same group to start preliminary work on the design and construction of a research reactor for the Atomic Weapons Research Establishment. The reactor will be a slightly modified version of the one being built at Aldermaston Court. This reactor, the U.K.A.E.A. states, will be used to obtain fundamental data required in the fields of weapons development and reactors for military purposes. In this connection it should be noted that in the Authority's Annual Report it was said that the Weapons Group would in future have responsibility for research into and development of nuclear reactors for military application.

Future Reactor Systems

In its second annual report, published in July, the U.K.A.E.A. said that a considerable amount of work was being done on what it termed stage 2 and stage 3 reactors. Stage 2 reactors are ones that would provide higher heat ratings than gas-cooled reactors, but would require enriched fuel. Systems in this class that are being studied are the pressurised water and sodium cooled graphite reactors. An alternative to the pressurised

water system is the organic liquid moderated and cooled reactor, which avoids the necessity for high pressures. Stage 3 reactors are ones in which it is hoped to obtain a much higher fuel utilisation by the achievement of breeding. Four systems are being investigated by the Authority :

(i) Fast reactor (a fast reactor is already being built at Dounreay and ZEPHYR and ZEUS are in operation).

(ii) Homogeneous aqueous reactor.

(iii) Liquid metal fuelled reactor.

(iv) High-temperature gas-cooled reactor.

At a conference held at Harwell on November 30 work on these systems was described to 200 representatives of British industry. It is now apparent that though the development of large base-load power reactors for Britain's own nuclear power programme will continue to, and in fact must, have first priority for many years to come, both industry and the Authority are beginning to turn their thoughts towards the small power reactor giving an output of between 10MW and 30MW of electricity. Such a reactor might be a very attractive system for the export market. It seems possible that one of these reactors such as the organic moderated liquid reactor, could well be a candidate in this field. This particular reactor is also being studied by a joint team from Harwell and the British Shipbuilding Research Association as a possible ship propulsion system. In considering the export market, power at a cost of something over a penny a unit may be quite an economic proposition. In fact, it is probable that absolute simplicity of design and reliability of operation would be the dominating requirements.

Both the liquid fuelled reactor systems being studied require an extensive programme of test work in loops under irradiation and for this work the DIDO and PLUTO reactors are essential. Even so, it may not be possible to resolve all the problems associated with these more complicated systems without building reactor experiments and the Authority stated in its report that one or two of the stage 3 reactors may be chosen in 1957–8 to proceed to a reactor experiment.

Maintenance of Reactors

The British Nuclear Energy Conference is undoubtedly proving to be a very useful association of engineers and physicists for disseminating information on reactor technology. The nuclear engineer is indeed fortunate, and probably there are engineers in other fields who feel that they would like the equivalent of the B.N.E.C. in their own particular line to give co-ordination to the many papers and discussion that are read to the various professional bodies in the country.

Apart from the Calder Hall symposium the B.N.E.C. sponsored a wide variety of excellent papers during the year. One of these was presented before the Institution of Chemical Engineers on May 3. It was entitled " Some Problems in the Maintenance of Nuclear Reactors," and given by Mr. H. G. Davey, the works general manager of the U.K.A.E.A.'s Windscale works. This paper decribed how repair work on the burst slug scanner gear was done at the back face of one of the Windscale piles. During an inspection in reactor No. 2 in May, 1955, a scanner guide shoe bracket with four holding bolts, sheared and still in position, was found in one of the skips holding discharged fuel elements. The shoe itself had been sheared off and was missing. A quick inspection of the reactor confirmed that the right-hand bracket of No. 7 scanner was missing and that the guide rail bolted to the scanner had broken loose. The remainder of the brackets and guide rails were in position. A radiation survey was carried out and the general level in this area found to be such as to give a dose of 80 roentgen to anyone remaining in the area for eight hours. Considering that the weekly maximum permissible dose was 0·3r. the problem of doing any repair work in the area will be recognised. The fact that eventually such a repair was effected without hazard to the personnel was a masterly achievement. It was impossible to fit a new foot-step bearing, but a perfectly satisfactory roller guide was fitted instead.

A first impression from this paper is that it shows that maintenance inside a biological shield is possible under certain circumstances, and one perhaps feels that with experience it will be reasonable to accept maintenance of parts of a reactor as a possible way of reducing capital costs. The experience recorded in this paper must influence design of future reactors. But it is important that reactor designers study the paper and learn the right lessons from it. This particular piece of maintenance could well become a classic in this field. Whatever may be done later in the way of major maintenance operations in highly active areas, they will all to some degree have to follow this same pattern —a pattern that in many ways will be more familiar to a member of one of the armed services rather than the civilian engineer. The assessment of the problem, the survey of the degree of hazard, the working out of a solution, the preparation of a timed programme, the provision of intercommunication facilities, the rehearsals of the operations to be carried out until everyone concerned was completely familiar with the drill—all these were the necessary preludes to the final execution, which was carried out under the most strict control. Because of the time limit imposed on each individual 251 people were involved in the operation and the control of radiation exposure was successful. What is the reactor designer to learn from this ? It appears to us that there are two fundamental points. First, that any work involving a man entering a highly radioactive area, however simple the job he intends to carry out, must be planned and controlled like a military operation. The second arises from the first, and is that access is all-important. Fig. 1 shows how access was gained at the Windscale works. The reactor designer must appreciate the first point if his thinking about the second one is to be correct. If any part of a plant in a highly active area might need maintenance then the designer must provide some access to it. It need not necessarily be for a man to get in. With modern facilities, such as industrial television cameras and remote handling equipment, much can be done through comparatively small diameter holes. On the other hand, if there is a possibility that a man may have to go in to cope with some emergency situation, then it is essential that the access is good and he can move about readily and easily. It must be borne in mind that he may have to wear breathing apparatus and special clothing, all of which will restrict and slow down his movements. Mr. Davey's paper is extremely valuable, as it represents the views and experience of people who have now been engaged in operating reactors and industrial radioactive chemical plants for many years. It is hoped that the B.N.E.C. and the U.K.A.E.A. will encourage the publishing of more papers reviewing operating experience, for if the nuclear power industry is to develop smoothly the operators' problems, difficulties and know-how must be fed back to the designer as rapidly as possible.

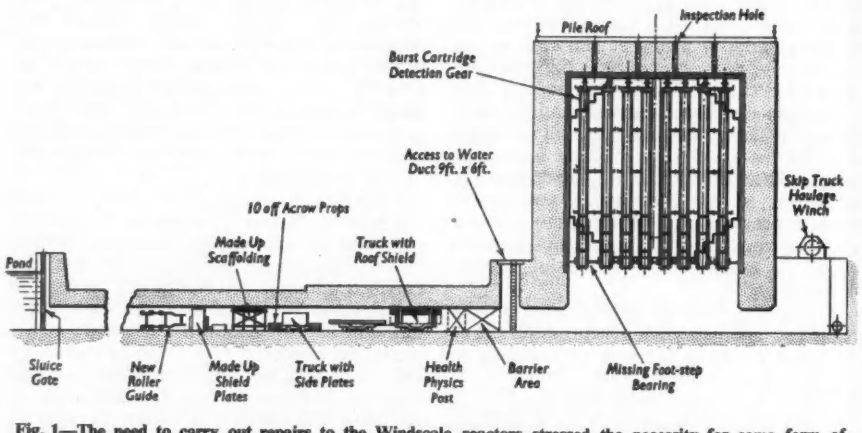


Fig. 1—The need to carry out repairs to the Windscale reactors stressed the necessity for some form of access to the working parts of a reactor within the biological shield. This drawing shows how access was gained to the Windscale reactor through the water duct ; and how the repair equipment was marshalled in the duct

Nuclear Engineering Education

In September the Harwell Reactor School was moved into bigger buildings to allow more students both from this country and from overseas to be accommodated. The number of courses was also increased. In future there will be two courses. There will be the standard three-month course, designed to give graduate engineers and physicists a good general background in reactor technology and, in addition, a six-week course which is concerned mainly with the fundamental physical and engineering principles in reactor design. The shorter course is intended primarily for lecturers from universities and technical colleges, and the staffs of firms working on ancillary aspects of the nuclear power programme. In addition to this the Authority have held a number of conferences at Harwell to acquaint members of industry with some of the work that the Authority is doing. From being hedged around by security restrictions, a few years ago, we have now moved to a stage where the majority of the general public must be more familiar with what the inside of an atomic energy plant looks like than any other. Yet it would probably be true to say that many people are still uncertain as to what type of engineer is required for this work. The new and rapidly expanding nuclear power industry will require to draw

heavily on the nation's technical resources and there are many young men now entering our engineering courses at universities who will eventually be working in or on the fringe of this field. That the universities have a part to play has been recognised for a long time. The question has always been, what part? Should any aspects of nuclear engineering be taught in already overloaded undergraduate courses at the expense of some other subject or should it only be dealt with at post-graduate level? Several universities have now come to grips with the problem and no doubt in the next few years the pattern of education in nuclear engineering will become clear.

During the past twelve months chairs have been created in two of the engineering departments of London University and a number of lecturers have been appointed at other Universities. The danger at the moment, if any danger can be said to exist, is that too great an emphasis may be placed on nuclear physics, especially in Universities where the physics taught in engineering departments is not under the direct control of the department concerned. Few engineers in this new industry will be engaged in nuclear calculations; and even these will be more concerned with the correct manipulation and interpretation of data in order to obtain a useful result, than in analytical studies. After all, engineering construction has gone a long way by making deductions from stress-strain diagrams, without insisting that engineers should first understand what is happening to the crystalline structure of the metal, or why intercrystalline forces may vary. It must not be forgotten that design of nuclear reactors can only be the result of team-work among engineers and scientists. If the engineer is to play his proper part he must know enough of nuclear physics to link up with the nuclear physicist just in the same way that he must have some knowledge of metallurgy to understand and appreciate the metallurgical problems and the work the metallurgist must do. But to maintain the balance of the team he must be first and foremost an engineer, for it is in that field that he makes his own and vital contribution to the success of a project. The real need is not solely for nuclear specialists but to a larger extent for well-trained engineers, many of whom will need to be expert in an orthodox branch of engineering, with additionally a knowledge of nuclear engineering.

Calder Hall

On October 17, on a glorious autumn day in West Cumberland, Her Majesty the Queen formally opened Britain's first atomic power station at Calder Hall and electricity from the station began to flow into the national grid. On that day a new branch of the electricity generating industry came into being. To-day the gas-cooled, graphite-moderated reactor looks to have a future far brighter than many people seemed to think a year ago. After the Geneva Conference there were quite a number who looked upon the gas-cooled reactor as being already obsolescent, and eyes were turned to the more complicated reactor systems as offering far greater hopes for the future. Yet it is as well to walk carefully over this difficult ground before we attempt to run, and it must be remembered that a comparison of systems on purely scientific grounds may be misleading. It is rarely possible to get an accurate picture of future engineering costs until the first plant has been built. A reasonable estimate of the cost of the first plant can usually be made, but the engineer will recognise that it will be on the high side and that he would expect to be able to build more cheaply on subsequent plants. Similarly with technical improvements. The progress that comes from developments in engineering techniques are rarely revolutionary. The ability, for example, to form and weld heavy plate to meet rigorous standards of inspection only comes from the gradual extension of experience gained on less thick material. The engineer in fact has considerable responsibility in deciding this question of which reactor systems may eventually produce power at competitive rates.

It was an engineering problem that led the Americans not to pursue the building of gas-cooled reactors; i.e. the difficulty of obtaining sufficiently large gas blowers. Since the design and construction of Calder Hall was put in hand it has been seen that it will be possible to extend and develop some of our engineering techniques and thus permit a considerable reduction in capital costs to kilowatt. For example, when Calder was planned, it was considered that 2in thick plate was the thickest that could possibly be handled and welded on site. From experience gained at Calder there is now complete confidence that reactor vessels can be satisfactorily built in 3in plate. This enables higher gas pressures to be used and greater outputs to be obtained from stations no larger than Calder. From experiences such as these, coupled with the fact that the nuclear performance of Calder is better than was at first predicted, and with metallurgical developments holding out prospects of eventually producing fuel cans that will work at high temperatures, the general opinion has now swung round to looking upon the gas-cooled, graphite-moderated reactor as being a system with a very promising future indeed. In his introduction to the B.N.E.C. Symposium on November 22, Sir Christopher Hinton, although pointing out that the eventual trend will be to reactors of high rating, said that in his view "the merits of the Calder Hall type of reactor and the potential improvements which can be made in its design are such that plants of this type will still be built twenty-five years from now."

Industrial Participation

During the year the four groups of industrial companies that had been formed to study the Calder type reactor in collaboration with the Industrial Group of the U.K.A.E.A. completed their reactor proposals, and in October submitted tenders to the Central Electricity Authority for the first two nuclear power plants on which it was planned to start construction at the beginning of 1957. These tenders were then examined by the C.E.A. in conjunction with the A.E.A. and the result announced on December 14. The A.E.I.—John Thompson Nuclear Energy Company, Ltd., was awarded the contract to build the station at Berkeley in Gloucestershire, and the Nuclear Power Plant Company the station at Bradwell in Essex. At the same time a contract for a station with an installed capacity of 360MW was placed by the South of Scotland Electricity Board with the G.E.C.-Simon-Carves Group. It is also likely that a contract will be let to the English Electric group of companies to build the third station for the C.E.A. at Inkley Point in Somerset. It is expected that the cost of power from these stations will be somewhat less than 0·7d. a unit. The capital investment involved will be considerable. The Scottish station is likely to cost between £35,000,000 and £45,000,000, and the C.E.A. estimates that more than £120 million will be spent on the three first stations between now and 1960. These costs work out at something between £100 and £120 per installed kilowatt. As expected the capacity of these stations will be considerably greater than was originally anticipated by the White Paper Programme.

So ends a most intensive competition, and there is little doubt that the four groups are now four very powerful units in this field. Other firms, however, have not been idle. Crompton Parkinson, Ltd., are now forming a fifth group in collaboration with Richardson's Westgarth, and two other groups have been active in other fields. Vickers Nuclear Engineering, Ltd., a company formed by Vickers-Armstrongs, Rolls-Royce and Foster Wheeler, is playing a substantial part in the development of a nuclear submarine, and the Hawker-Siddeley Nuclear Power Company, Ltd., is studying liquid-metal-fuelled reactor systems.

The Nuclear Power Programme

During the year it became increasingly apparent that the programme for the development of civil power stations contained in the Government White Paper of February, 1955, was no longer a realistic assessment of the true possibilities. Increasing confidence in the gas-cooled reactor, coupled with the building up of the industrial teams into potentially powerful design and construction units all led to the feeling that the original programme was too conservative. The Suez crisis and the cutting of our oil supplies gave point to this opinion, even though it was recognised that it would be a long time before nuclear power could contribute more than a fraction to our total electricity generating capacity. One reason for caution in stepping up the nuclear power programme is that nuclear stations cost more to build than conventional stations, although their operating costs are lower. The present designs are only suitable, therefore, for base-load power stations where the high load factor can be set against the high capital charges. Even so, it would come as no surprise were the Minister of Fuel and Power, Mr. Aubrey Jones, soon to announce that the rate of building nuclear power stations were to be increased.

But before agreeing to a revision of the White Paper programme, Government officials, in conjunction with the A.E.A. and the C.E.A., must satisfy themselves about the availability of the special nuclear materials required to meet this programme. In March, 1956, it was announced that the U.K.A.E.A. had, with the consent of the Government of the Commonwealth of Australia, entered into a contract with Mary Kathleen Uranium, Ltd., a member of the Rio Tinto Group of Companies, to buy for a number of years uranium concentrates to be produced in the Mary Kathleen mine in North-West Queensland. The U.K.A.E.A. undertook to lend up to £5,000,000 to bring the mine into production, and the Government of the State of Queensland has said that the project will make an important contribution to the development of the north-western part of the State. Later in the year, the U.K.A.E.A. announced that, in continuation of the tripartite co-operation between the United States, Canada and the United Kingdom, it had entered into negotiations with Eldorado Mining and Refining, Ltd., for the delivery of a substantial quantity of uranium before March 31, 1962. The Authority is also fostering an interest in uranium prospecting in other parts of Australia and the Central African Federation.

Another vital material required for the

civilian power programme is graphite, for use as the reactor moderator. So far British Acheson Electrodes has been the only firm able to supply the quality of graphite required. Towards the end of the year, however, C. A. Parsons, Ltd., in conjunction with several of the companies associated with it on atomic energy work, decided to build a factory for the production of reactor-type graphite in partnership with the Great Lakes Carbon Corporation in New York. The latter company is the second largest producer of this type of graphite in the United States. The factory is expected to cost about £6,000,000, and it has been said that it will be completed in two years' time. Its output is given at 10,000 tons a year. The demand for steel for these nuclear stations will also be nearly twice as much as it would be for conventional power stations of the same capacity and a far greater proportion will be required in the form of plate.

But, given the special nuclear materials and steel, can British industry meet the challenge offered by the power programme, a challenge which, at the B.N.E.C. Symposium on Calder Hall, Sir Claude Gibb stated, industry would welcome ?

We think it can, but it will certainly call for a reorientation of ideas in many, perhaps even in some unexpected, corners of industry. The major industrial groups concerned, following their experience gained in preparing tenders for submission to the C.E.A., should be able to prepare their detailed designs with confidence. It is, however, in the construction and fabrication stages of the work that we believe the strain of meeting the programme will be most apparent. The Industrial Group of the U.K.A.E.A. has made it a cardinal principle of its organisation that the chief engineer in charge of the design of each one of the reactors or chemical plants remains in complete charge of the job until the plant is eventually handed over to the operating staff. The arrangement has not been one of mere convenience ; the Authority has found it essential when building plants of this kind to have a clear and unchanging centre of responsibility for all stages of the work. This is not surprising, and many would say that it is an obvious thing to do. But on the majority of plant installations carried out in this country the designer has little direct control over shop fabrication or outside erection. With conventional plants good standards of practice have been built up over many years, and with this sort of traditional background it is the outside erection staff which usually has the real knowledge on construction matters. When we look at nuclear power plants, however, the position is completely different. The standards of construction and fabrication are far more stringent than is common practice. This time it is not the outside staff, with its experience of knowing how to meet a particular specification, which will be best able to give the right lead ; instead it will be up to the designers to satisfy themselves that the right decisions are given to the many problems that will inevitably arise in the construction of these new stations. These problems may appear to be small, the sort that one would normally leave to the man on the spot, but as maintenance on parts of the plant may be impossible once the reactor is in operation it is essential that an engineer, fully conversant with the purpose of each part of the reactor and with knowledge of the design background, must be in touch with the job throughout and have ultimate control.

Reactor construction also demands an integration of civil, mechanical and electrical work during site construction that can only be met by the most careful and elaborate planning. Again, this is so fundamental as to carry with it the danger that it will not receive the top level impetus it requires. But successful planning is a skilled operation demanding a dynamic approach and one which must carry authority. If not, it deteriorates into little more than maintaining a record of target dates—target dates that have probably not been met.

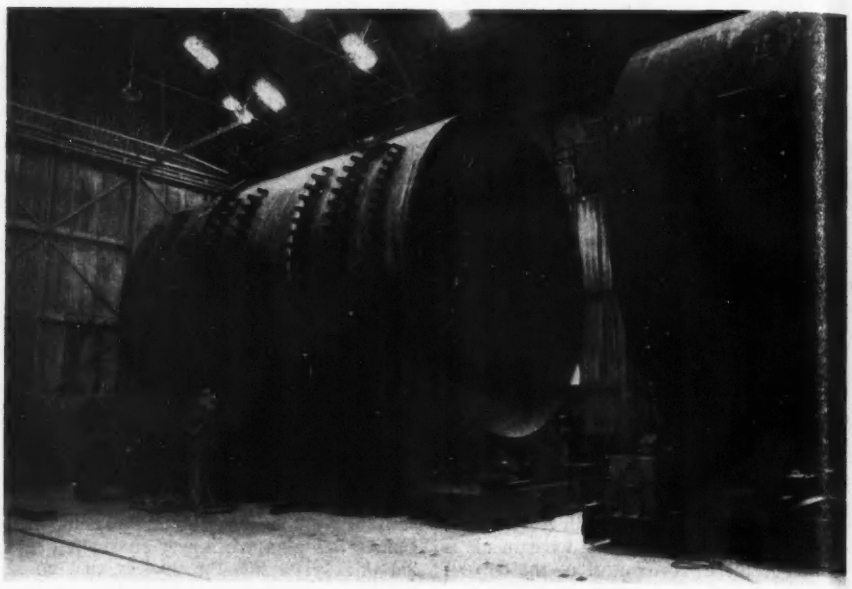


Fig. 2—Stress relieving a Calder Hall heat exchanger in the Babcock and Wilcox site workshop

Another change from normal practice is that far more fabrication work will need to be done on site than is customary. At Calder Hall both Babcock and Wilcox and Whessoe did the major part of such work at site and not in their own workshops. In future it will mean that plate preparation will be done in a contractors' works, but welding, radiographing, stress relieving, &c., will all have to be carried out on the site (Figs. 2 and 3). And it must be remembered that the standards of workmanship demanded will be consistently higher than the contractor has probably had to meet previously in his own shops. There will therefore be a need, not only for skilled tradesmen for site fabrication, but also for a very high standard of site inspection and supervision. The latter will also be required when it comes to doing work under " clean conditions," which are essential inside the reactor shell and the gas circuits (Fig. 4) during and after graphite laying. The whole concept of doing large parts of the work under clean conditions is a revolutionary one, and even such matters as arranging the laundering of overalls and other clothing which must be worn in clean areas must not be overlooked.

Finally, no matter how good the actual fabrication or how rigorous the site control, the quality of the job can only match the quality of materials used. For example, inspection methods comparable with those

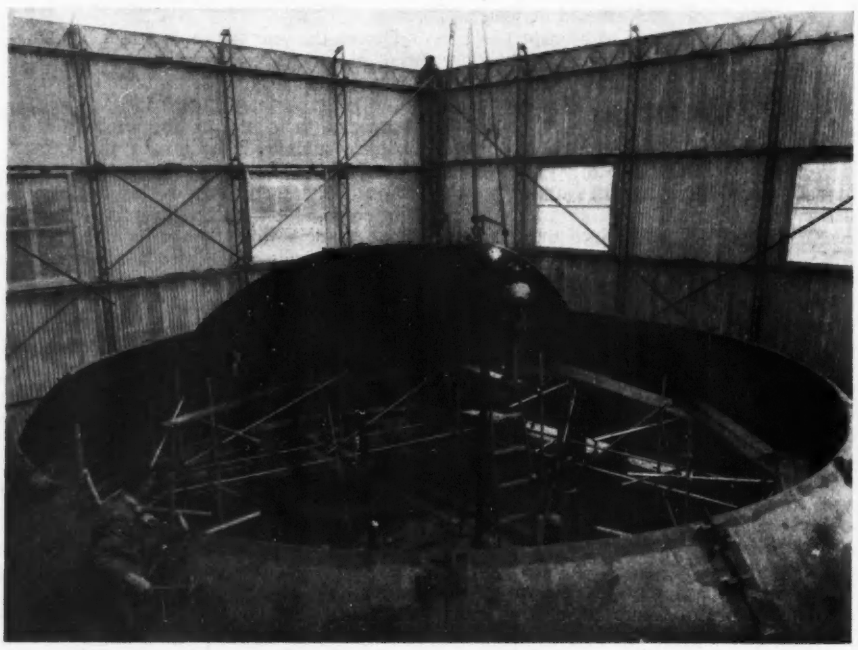
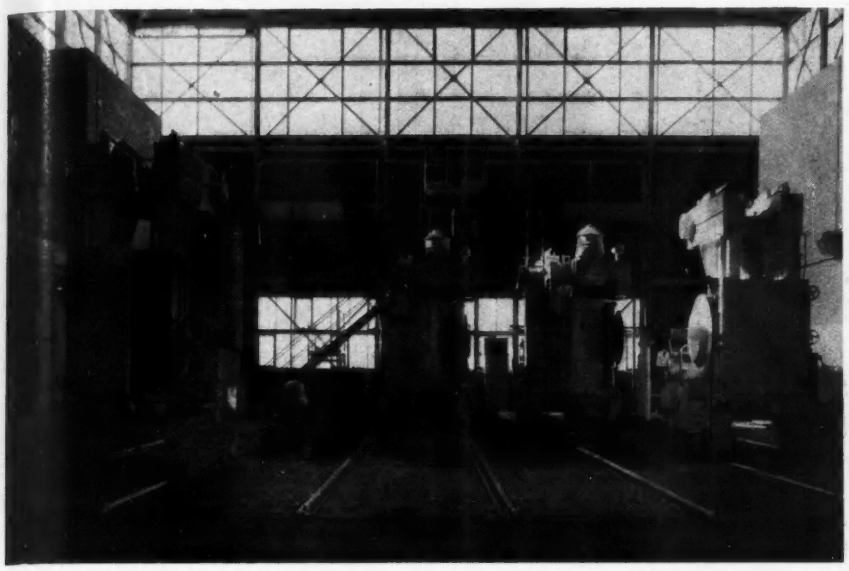


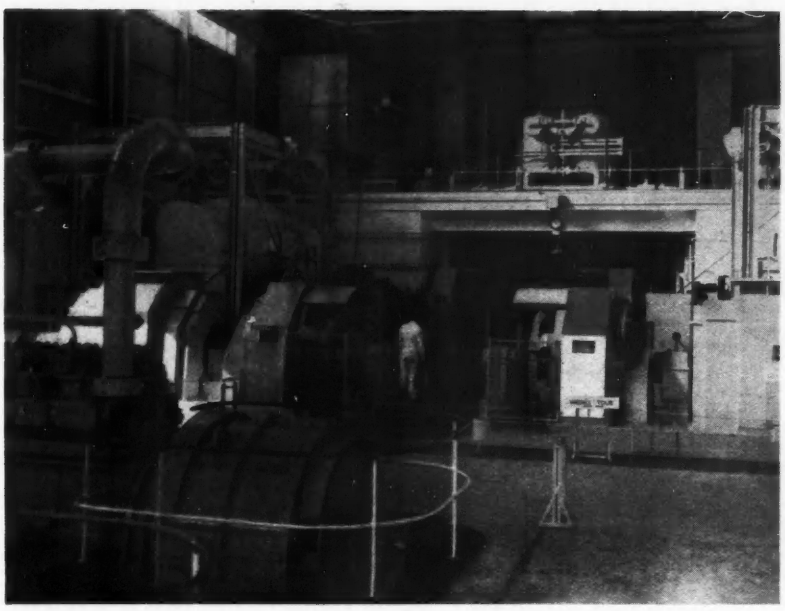
Fig. 3—The Whessoe area during the construction of Calder Hall, showing the fabrication of the top dome of the reactor vessel

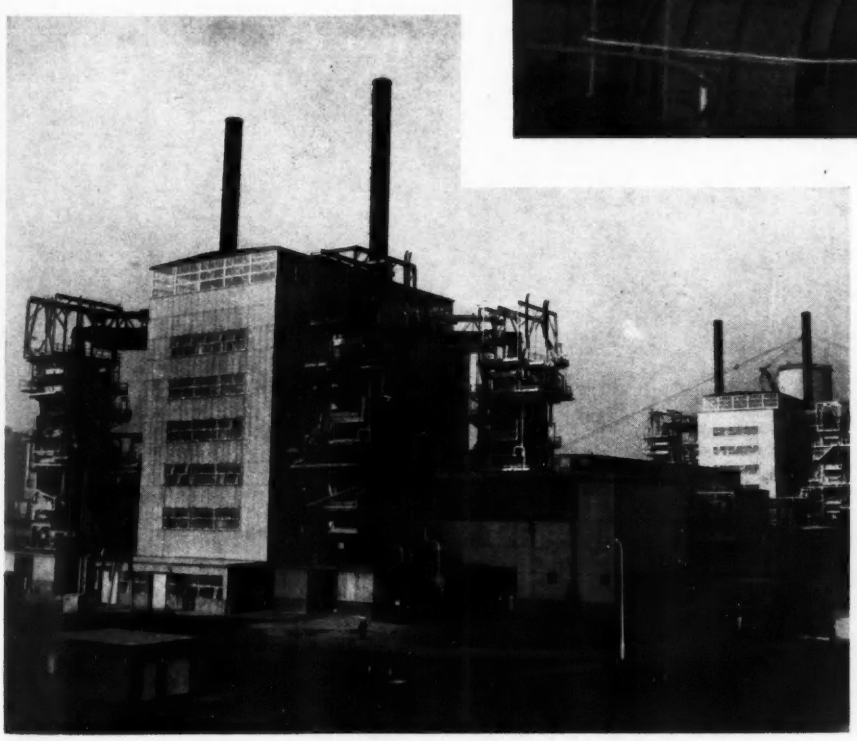
CALDER HALL NUCLEAR POWER STATION



The first large-scale nuclear power station in the world was opened at Calder Hall, Cumberland, by Her Majesty The Queen on October 17. It is designed for the dual task of producing plutonium and generating electricity through the medium of gas-cooled graphite-moderated reactors, using natural uranium fuel elements. Advanced versions of these reactors, "optimised" for power generation, will form the basis of the stations to be built in the first phase of Great Britain's nuclear power programme. Each of the Calder Hall reactors is enclosed in a welded steel pressure vessel, built up of plate, 2in thick, surrounded by a thermal shield of steel and a biological shield of reinforced concrete. The fuel elements are arranged in vertical channels in the graphite lattice and they are handled from the charging floor (illustrated here) which is vertically above the reactor. Rails on the reactor floor provide the shielded discharging and charging machines with access to any of the fuel element channels and the machines are equipped with motor-driven winches and elaborate instrumentation for the remote handling of the fuel elements

Heat is abstracted from the Calder Hall reactors by circulating CO_2 gas, at a pressure of 115 lb per square inch abs., through the reactor. The hot gas emerging from the fuel element channels at the top of the reactor are circulated through separate ducts to four heat exchanger towers in which the heat is given up to nests of tubular elements in which steam is generated. Associated with each of the heat exchangers there is a main circulator (illustrated here), which consists of a horizontal-shaft centrifugal impeller rigidly coupled to a d.c. driving motor continuously rated at 0/1500/2200 h.p. when running at 0/854/940 r.p.m. The impeller is overhung, an arrangement which requires only one shaft seal and, therefore, simplifies containment of the gas. The shaft is carried in four journal bearings and the bearing inboard of the driving motor incorporates a Michell thrust block. A Ward-Leonard system provides the required 10 : 1 speed range of the main circulators. A standby against failure of the main drive is provided by a 15/100 h.p. d.c. pony motor which is installed above the circulator shaft and drives it through a free wheel and gear train. Power for this pony motor comes from the station's guaranteed d.c. supply



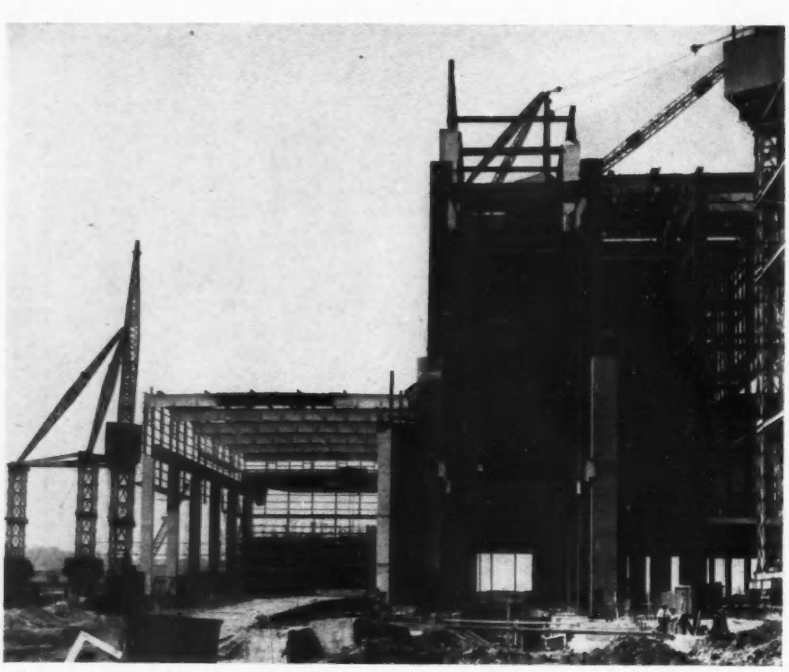


Our third illustration gives a general view of Calder Hall "A" station which has two reactors, separated by a common turbine hall and administrative block. In each of the eight heat exchangers steam is generated on a dual pressure cycle without reheat, the h.p. and l.p. systems being provided with separate drums and superheater, evaporator and economiser sections. There are four turbo-alternators, each rated at 23MW, 11·5kV, 3000 r.p.m. The turbines are reaction machines, having a single-flow h.p. cylinder and a double-flow low-pressure cylinder. About three-quarters of the total intake of steam by each turbine is taken into the high-pressure cylinder at 185 pounds per square inch gauge and 590 deg. Fah., and the remaining quarter into the l.p. cylinder at 40 pounds per square inch gauge and 340 deg. Fah. At turbine exhaust the vacuum is 1·75in Hg abs. and the estimated wetness is 11 per cent. Since the total heat of the reactors must be absorbed continuously the turbines normally operate under steam pressure control. If the reactor heat output should exceed the demand from the turbines the excess steam is discharged to dump condensers. A duplicate station, to be known as Calder Hall "B," adjoins the existing "A" station, and is due to be completed next year

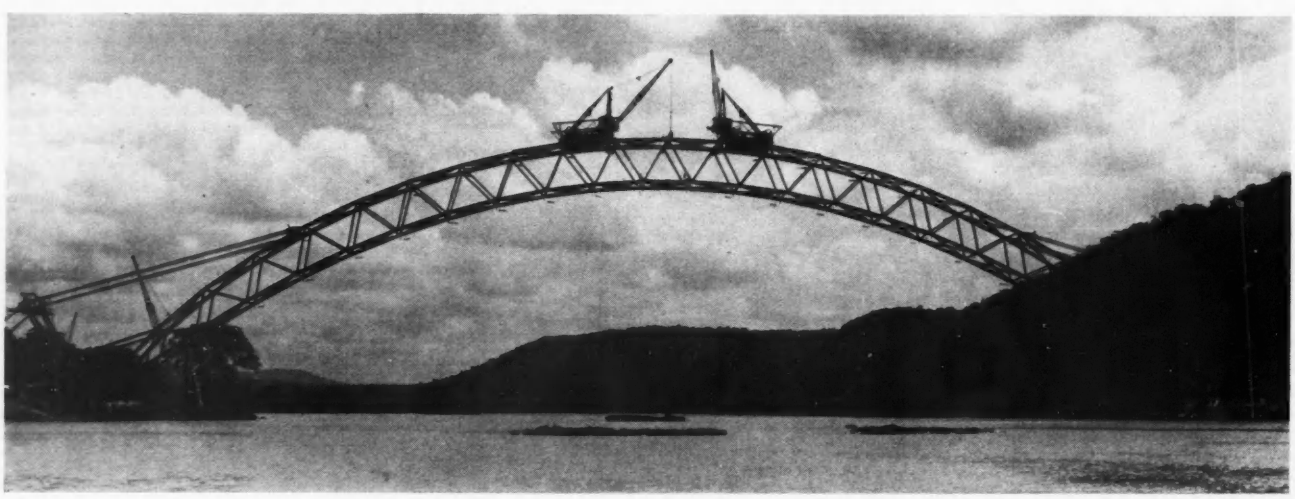
HEAVY STRUCTURAL STEELWORK

The passenger and cargo building at Southampton, shown under construction (right), was opened early last year. It is of special interest because the "collapse load" method of design was used for the first floor steelwork, probably for the first time on a job of such magnitude. Heavy loads are carried over appreciable spans, and welding and automatic fabrication were employed. The roof trusses span 108ft, and were prefabricated with rafters propped on each side, so that complete bays of roof steelwork were erected as a unit. The Southampton Docks engineer is Mr. J. H. Jellett; consulting structural engineers were Scott and Wilson, Kirkpatrick and Partners, and the steelwork contractor was the Fairfield Shipbuilding and Engineering Company, Ltd. See "The Engineer." February 3 last

Castle Donington power station reached the stage of generating power this year. The steel structure of this station (below) comprises welded shop-fabricated assemblies, with site joints bolted or riveted. The columns are of box section, and the boilers are suspended from the roof steelwork. Consultants: Freeman, Fox and Partners; steelwork contractor, Sir William Arrol and Co., Ltd. See "The Engineer," May 25 last

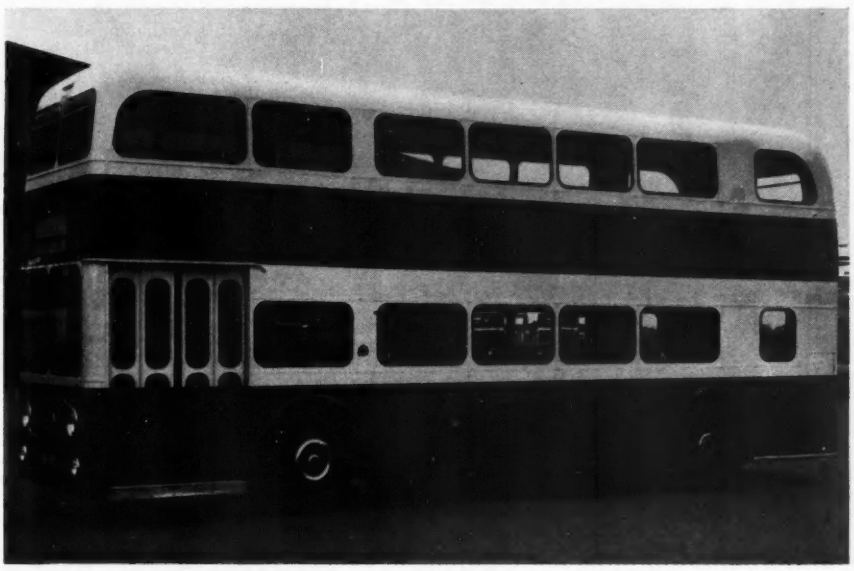


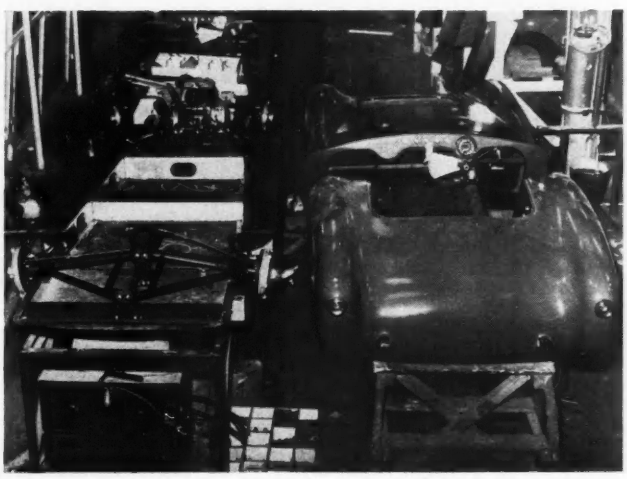
On July 26, 1956, a very large high-tensile steel arch was joined across the Volta River at Adomi, in the Gold Coast. The illustration below shows construction at this stage. The concreting of the deck was completed in October. The bridge has a clear span of 805ft and carries two lines of road traffic on a carriageway 22ft wide. There are footways on either side, each 5ft wide. Unusually clean lines have been given to the main arch steelwork, which is of high-tensile steel, by the design of the joints. The box section girders are pulled tight end to end, by bolts joining their end diaphragms. The bolting operation was carried out from inside the girders, and the whole joint is concealed. For its size the bridge is designed to sustain the exceptionally heavy British Standard HB 45 unit loading. The whole of the steel structure is metal sprayed with zinc and painting is not envisaged. The bridge approach spans are in reinforced concrete, using high-tensile steel reinforcement, and together they and the bridge carry a roadway at considerable height above the normal dry season river level. This is not to facilitate the passage of boats, but because the river has a very marked seasonal flood, and, on the basis of model experiments used for the Volta River project, the level to pass a flow of about 1,000,000 cusecs was chosen. Approach roads totalling 5½ miles have been constructed. These are to the Gold Coast tarmac trunk road standard, and, taken together with other road works now in hand, will provide very greatly improved communications between Accra, the capital, Tema the new port, and Togoland. At present crossings of the Lower Volta are all by vehicle ferries. The consulting engineers to the Gold Coast Government for the work are Sir William Halcrow and Partners, and Messrs. Freeman, Fox and Partners; the main contractor was Dorman Long (Bridge and Engineering), Limited

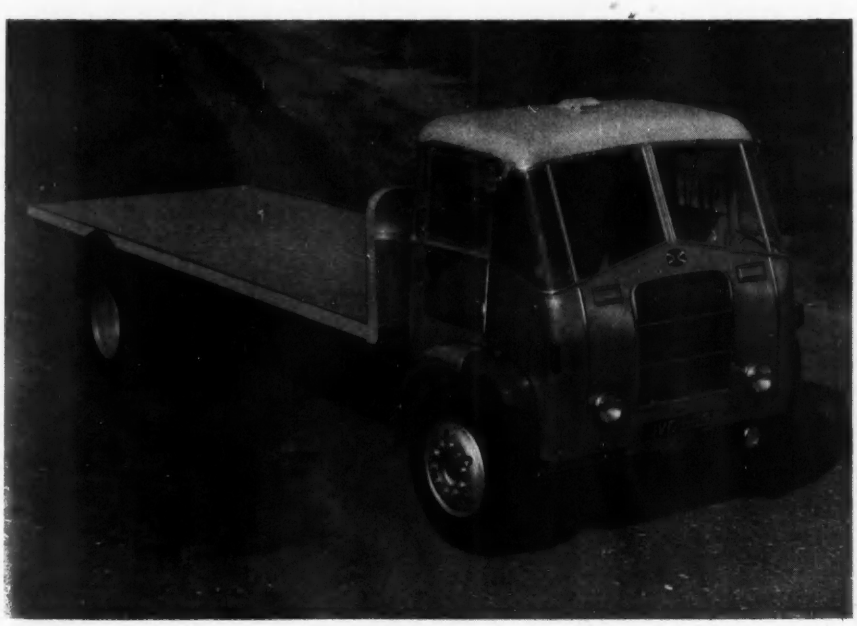


INTEGRAL CONSTRUCTION FOR ROAD VEHICLES

The Leyland "Atlantean" is of semi-integral construction, the suspension, power unit and controls being mounted on a steel girder plated with light alloy to form the unbroken floor of the lower deck, barely 18in above road level. An upper deck of centre gangway layout brings the overall height to 13ft 5in. Wishbone front suspension allows a tight steering lock, while the low and far aft engine mounting gives a c.g. position favourable for stability. Seventy-eight passengers are carried with an unladen weight of 7¾ tons and the power of an "0.600" engine of 125 h.p. at 1800 r.p.m. The Berkeley car has an overall weight less than 5½ cwt. Stressed skin construction has been adopted, the problems of stress concentration at cutouts being slight in a plastic shell. The engine and final drive and the rear suspension assemblies can be seen below in place on the glass-reinforced polyester underbody. The attachments are partly bonded and partly secured by hollow break-stem rivets. The weight of the car is transferred through bolted flanges into the front and rear upper body shells, the suspension loads being distributed by steel inner wheel bay panels. The centre portion of the body, having a shallow section, is reinforced by light alloy sheet members bolted in to give stiffness as a beam and in torsion. Unusual details are many: light unsprung weight is sought by incorporating the drums into the wheels, the brakes being very lightly loaded; adjustable suspension gives slight negative camber to the swung axles at all loads; the conventional light units have separate bulbs and a third transparency fairs them into the body without obstructing the dipped beam



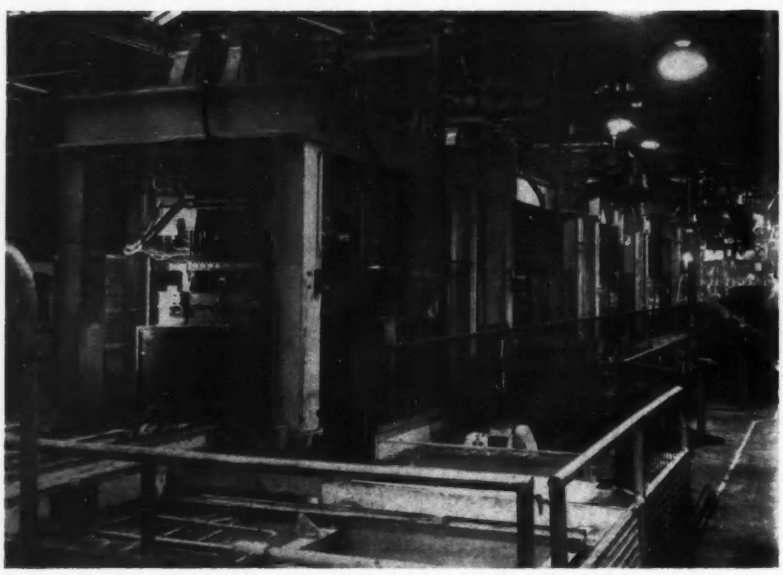




Integral construction has resulted in a truck able to carry a 10-ton payload without exceeding the 14 tons gross permissible on two axles. The taxation weight of this wagon, which was built by Mann Egerton and Co., Ltd., is only 3 tons 10 cwt. The 85 h.p. engine, transmission, front axle and suspension are Albion components, and the final drive is by an Eaton two-speed axle. The structure is basically a pair of deep light alloy pressings, ¼in thick, joined by diaphragms at intervals. The centre panel of the 7ft 6in wide tray is welded direct to this frame, while outriggers support the sides, and all are of aluminium tread plate. All welding is electric in argon shielding. The cab is light alloy, flexibly mounted on the frame and stiffened by extruded sections. The engine cowling is integral with the cab; the high conductivity of the metal is countered by admitting through the grille more air than the fan can draw through the radiator. It can be seen that effective cooling of the cowling is relied upon, there being only small opening windows. The vacuum reservoir is welded with consumable electrode, the radiator brazed, and the fuel tank welded with filler rod, all of aluminium alloy. Noteworthy are the American forged aluminium wheels; not only do they reduce the unspring weight by no less than 2 cwt, and also, of course, the rolling inertia, but their high conductivity is valuable in an application where cast iron brake drums (retained for ease of spares supply) are severely shrouded from the air flow. Michelin metallic tyres also save weight

HIGH-PRODUCTION AUTOMATIC PLANT

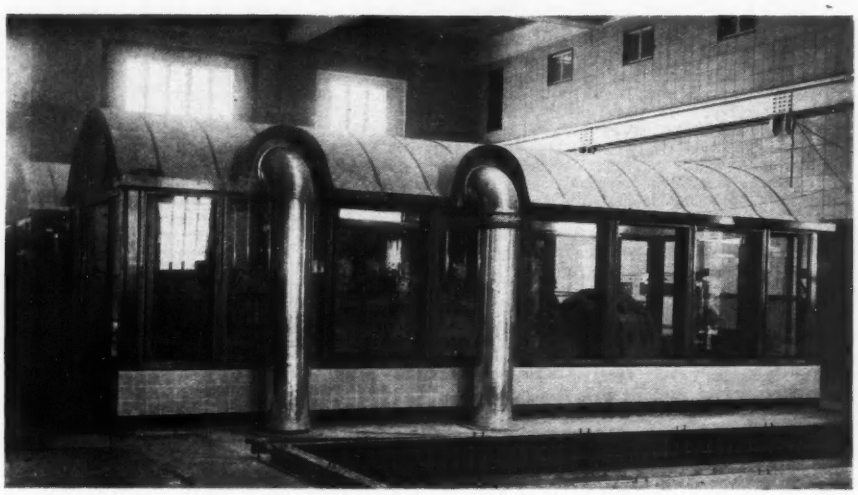
The characteristics of aluminium have presented a problem which had to be overcome before tubing in this metal could be made satisfactorily and economically in large quantities by welding. This problem has been solved and the firm of T.I. Aluminium, Ltd., is now producing welded tubing in aluminium and certain of its alloys on the machine illustrated on the left. This method is stated to permit not only very rapid production, but also a high degree of accuracy, both as regards diameter and concentricity. Welded tubes of up to 4in diameter are being made on the machine at present and there is no manufacturing limitation on length. The tubing is made from sheet shaped on rollers into the desired cylindrical form and automatically seam welded. It is claimed that there is no trace of a weld bead either inside or outside the pipes and as a regular routine all pipes are hydrostatically tested to 350 lb per square inch pressure. Bursting pressures are stated to be considerably higher, even up to 1200 lb per square inch



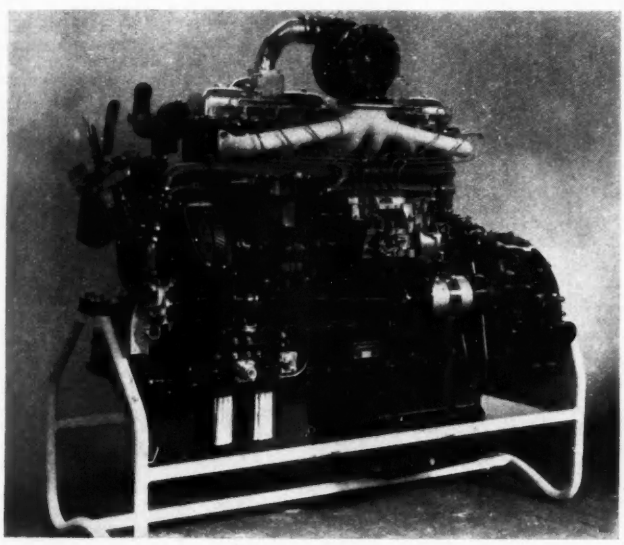
The conventional British car is composed of a box of steel sheet of moderate thickness welded into a single stiff shell. Consistently sound welding at high production rates, together with an accuracy of the order of 0·01in across the major dimensions of the vehicle, are needed. To achieve these objects in the production of the Mark II Ford cars, an automatic five-station welding plant has been installed in the Dagenham works of Briggs Motor Bodies. The components of an underbody, including the engine bay sub-assembly, are brought together upon a trolley running on rails. Pneumatic rams, electric motors and automatic brakes move the trolley across the far end of the plant and into the first press. The press raises the trolley to the live electrodes and welding commences ; the five presses are interlocked so that only one is taking current at a time. True series welding is used, and in order to allow a great many spots to be made at close pitches by a few machines, " shuffle " is employed, the live electrodes moving as much as 1½in between sequences. A total of 588 welds is made automatically and sufficient are completed in each of the first two stages for the underbody to be finished by portable welders ; thus, production is safeguarded against failure of any one press. In this picture the trolleys are moving towards the camera through the plant

Another high production machine used in the manufacture of aluminium tubes is the automatic triple-draw, high-speed drawbench on the left which was put into service last year at the Kitts Green works of James Booth and Co., Ltd. This machine was supplied by the Head Wrightson Machine Company, Ltd., and is fitted with control gear made by the Electric Construction Company, Ltd. It is designed to draw tubes up to 130ft long and is capable of exerting an effective pull of 60,000 lb. Tubes up to 2in diameter can be drawn three at a time and tubes up to 3in diameter singly, at draw speeds of up to 450ft per minute. In the automatic operating cycle of the machine three undrawn tubes are fed over three plug rods in the back-bench, while three tubes previously loaded are being drawn. On completion of the draw the back-bench is rotated to bring the undrawn tubes into line with the dies, and the plugs on which they are mounted are moved forwards until the tube tags protrude through the dies. During this movement the drawn tubes are ejected and the draw carriage is then returned to the die stand to grip and commence drawing the tubes previously loaded. Simultaneously, the next three tubes are fed over the other set of plug rods ready for the following cycle. This method of loading tubes whilst others are being drawn, combined with the high-speed operation, ensures maximum machine utilisation

GAS TURBINE AND DIESEL ENGINES



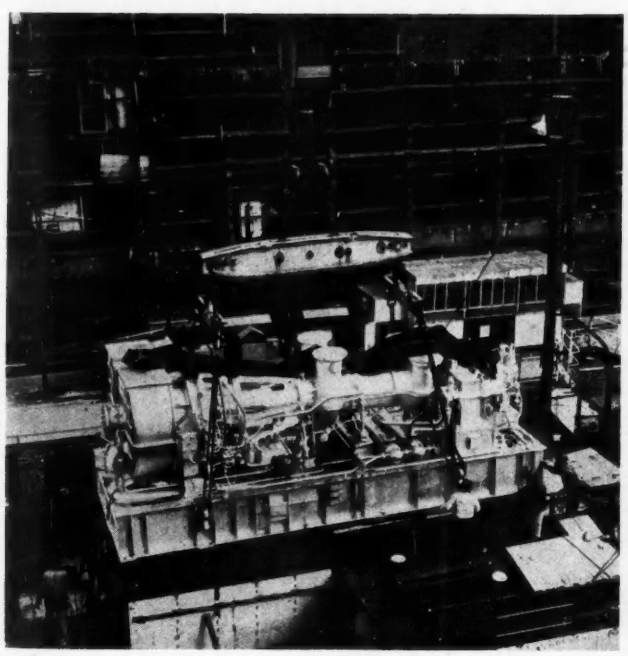
Each of the diesel-alternator sets installed in the power house of the Metropolitan Water Board's 90 m.g.d. filtration plant at Ashford Common is surrounded by a sound insulating booth, as illustrated on the right. The pumping plant at this station is electrically powered, from the grid, but 100 per cent standby generating plant is installed, comprising three gas-turbine-driven generators totalling 7250kW, and three General Motors diesel generating sets totalling 3300kW, one of which is shown here

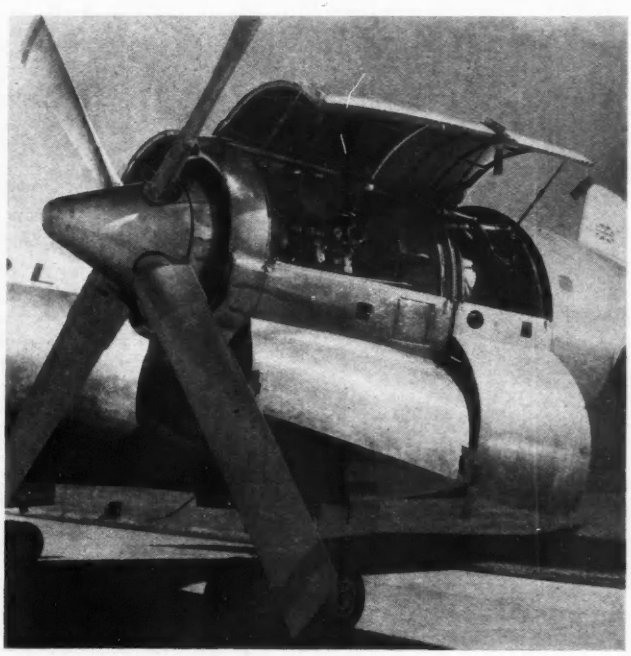


A feature of diesel practice where continuous running is involved has for some years been the turbo-charger, and this has now entered the automotive field. Turbines and compressors of very low inertia are required to follow rapidly the movements of the fuel rack, and on the Eberspacher blower seen on the left the rotor assembly weighs only 2·2 lb ; it runs on two ball bearings and speeds up to 38,000 r.p.m. are normal in service. The engine bearing it is a Thornycroft of 11·33 litres, installed in the " Big Ben " ; at 1900 r.p.m. it has an output of 200 h.p. or 155 h.p. unblown, and the fuel consumption is in each case just over 0·365 lb per b.h.p. hour. The vehicle's gross weight is 32 tons, but in articulated form can total 50 tons, or 40 tons unsupercharged

The term " supercharged " is also applied to the Bristol " Orion " turbo-prop (lower right), the compressors and turbines of which are large enough to maintain the maximum shaft horsepower of 4400 up to more than 10,000ft, with, of course, a reserve of power for tropical conditions or flap blowing. At 400 m.p.h. and 30,000ft the fuel consumption is only 0·38 lb per h.p. hour and 3080 e.s.h.p. are available. The installation seen here is on a " Britannia," designed for " Proteus " reverse-flow engines, and the cowling is therefore spacious. It is noteworthy that the twin-compressor engine, as installed in this aircraft, is actually lighter than the less powerful engine. Of the three small openings around the air intake, the lower pair supply the oil radiators and the uppermost cools the generator

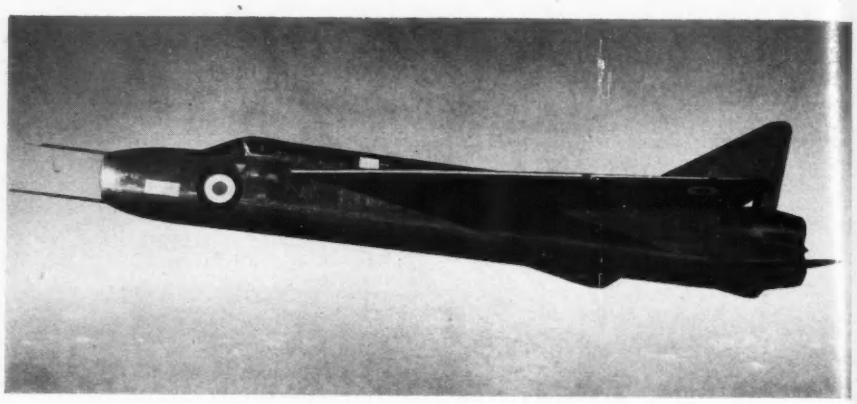
The lower left illustration shows a 6000 h.p., regenerative cycle, two-shaft gas turbine propulsion unit being installed last year in the rebuilt " Liberty " ship " John Sergeant " at Newport News. This ship is now the first American ocean-going gas-turbine-driven cargo vessel, and has a speed of nearly 15 knots. The gas turbine was manufactured by the General Electric Company ; it occupies less engine-room space than the propulsion equipment originally installed in these ships, burns a cheaper grade of fuel oil, and operates at a lower cost





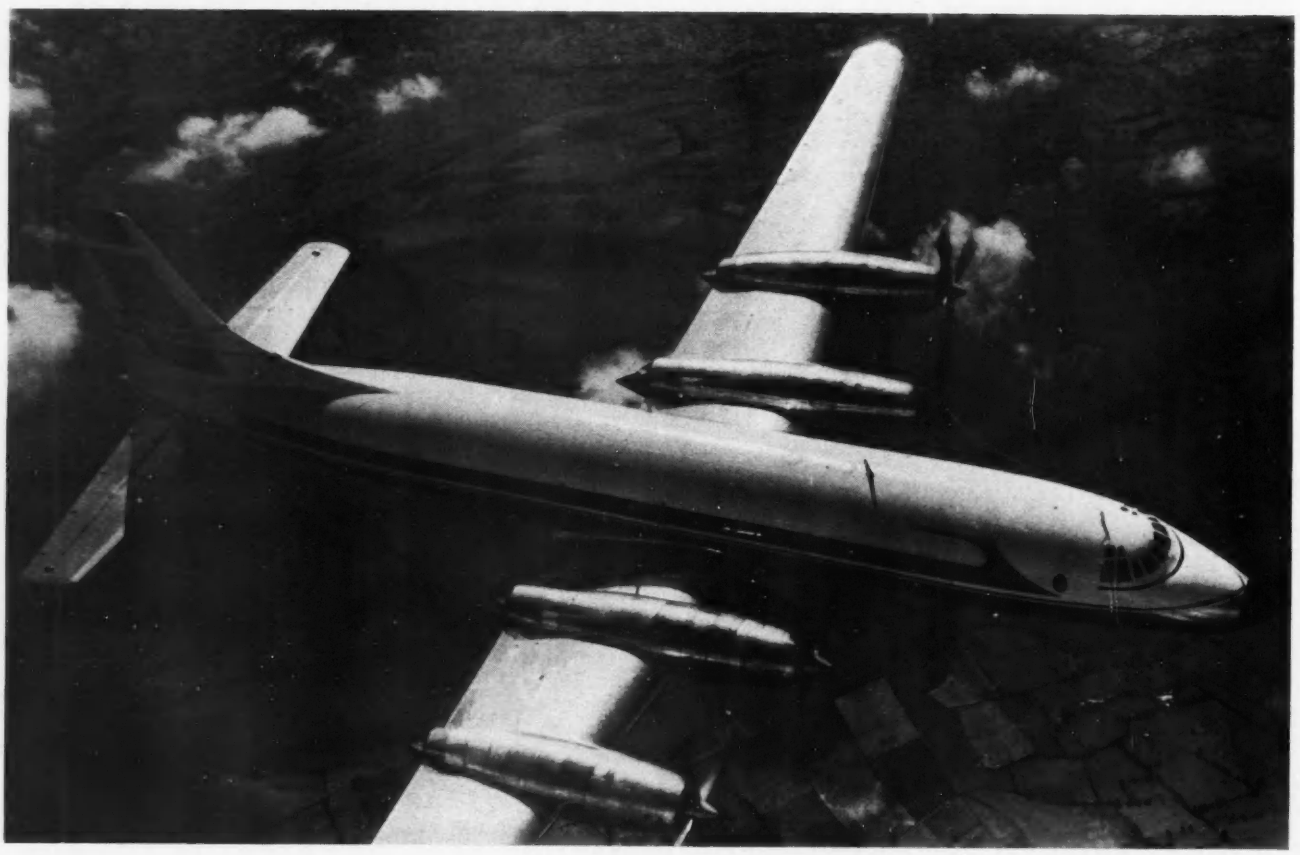
BRITISH AIRCRAFT

The English Electric P1 used, in prototype form, two Armstrong Siddeley "Sapphire" engines and first flew on August 4, 1954. Rolls-Royce "Avon" engines will be used in the twenty P.1 B pre-production aircraft and in the fighters for which a contract was announced in November last. This very large interceptor (right) can sustain a supersonic climb and 1000 m.p.h. has been claimed

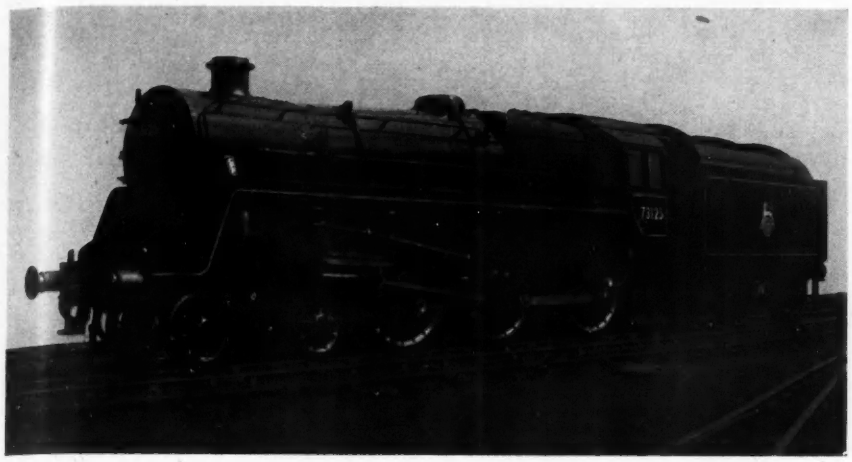


Prospective day fighter equipment for the Royal Navy is the Vickers "Supermarine" 544. This picture shows the large intakes feeding the two "Avon" engines, the contouring of the fuselage in accordance with the area rule—the 544 is supersonic in level flight—and the deep fences. The latter conceal the abrupt increase of chord at the leading edge, but the join of the hinged leading edge, extending to just inboard of the probes, can be discerned. This view foreshortens the nose, which is hinged to one side in front of the windscreen to enter carrier lifts. Production aircraft are intended to incorporate blown flaps to reduce the speed of the aircraft in the approach

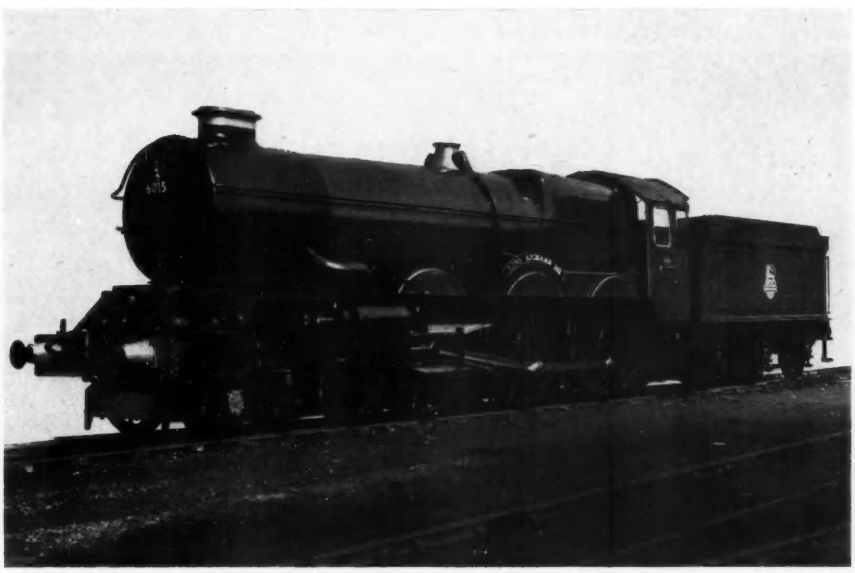
The prototype of the 300 series Bristol "Britannia" (below) made its first flight on July 31 last. It has a fuselage 10ft 3in longer than the earlier machines and is powered by "Proteus" 755 engines of 4120 e.h.p. The long range versions will carry their capacity payload over 4000 miles at 390 m.p.h. and accommodate 100 passengers. Its gross weight is 175,000 lb. The spring tabs of the previous fast Bristol aircraft have evolved into a pure servo system in which the pilot controls only the tab attitude; the numerous tabs are so connected that the aircraft can be steered by the rudder pedals instead of the column. The tail surfaces are balanced but the ailerons are spring-loaded down to conserve lift. In this picture strain gauging of the propeller blades of the port inner engine is in progress. An even longer and faster "Britannia" is projected to exploit the more powerful "Orion" twin-spool engines



STEAM LOCOMOTIVES ON BRITISH RAILWAYS

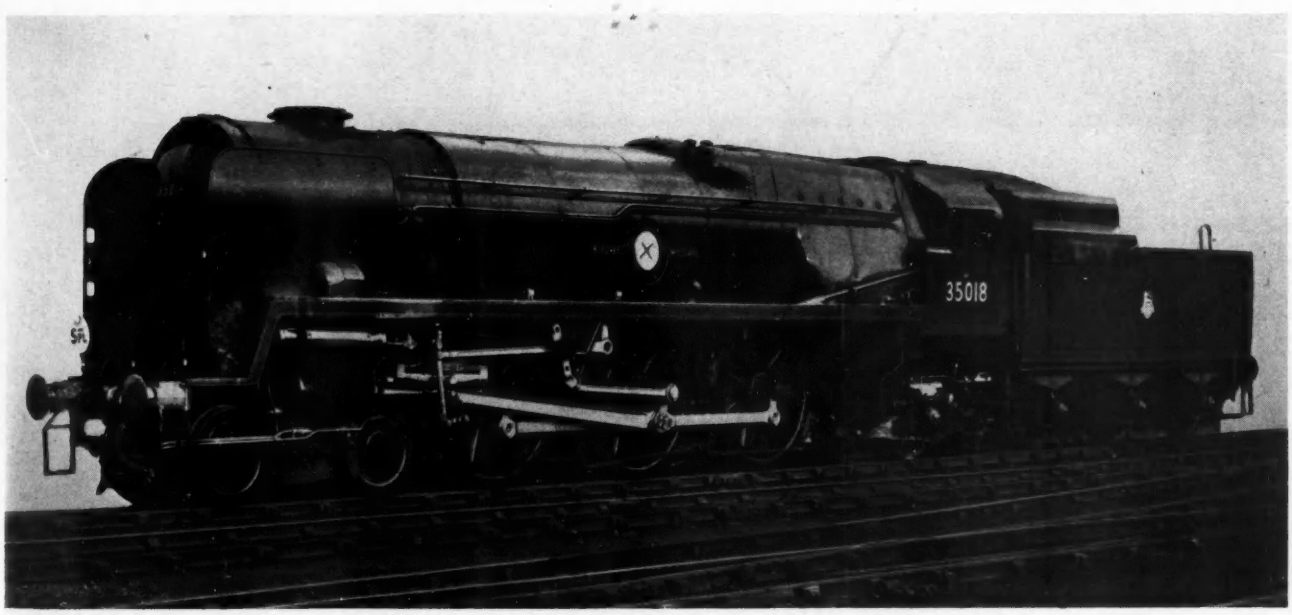


Although it is proposed under the British Railways modernisation plan eventually to replace all steam locomotives by electric and diesel traction, the steam locomotive will for some years at least continue to play a major part in railway operation. For this reason development work directed towards increasing the efficiency and economy of the steam locomotive is not being neglected, as is shown by the three locomotives illustrated herewith. The standard class "5" mixed traffic locomotive shown on the left is one of thirty which have been fitted with British-Caprotti valve gear. Ten each of these locomotives are being placed in service on the London Midland, the Western and the Scottish Regions respectively. It is to be expected that the fitting of this valve gear will increase the mechanical and thermal efficiency of these locomotives

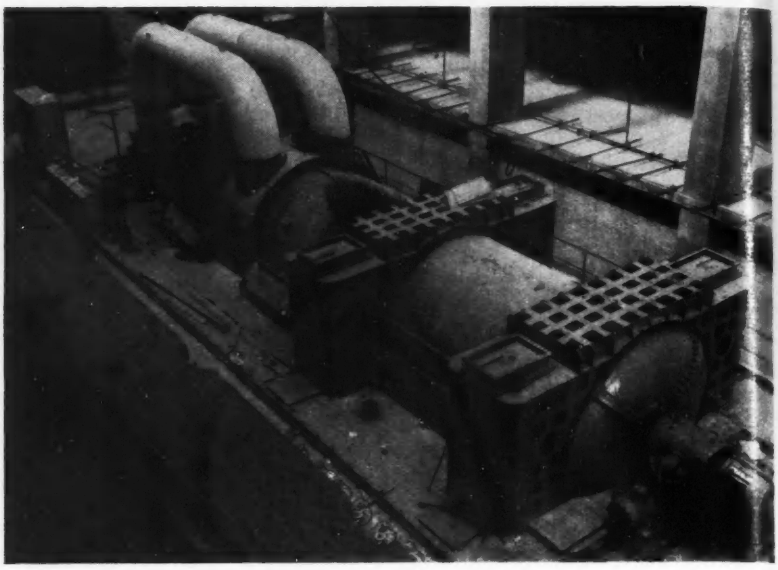


The "King" 4–6–0 express passenger locomotive (right) has been fitted with an improved draughting double chimney. The chimney removes the limitations to evaporation imposed by the single chimney previously fitted, the maximum continuous rate being now limited only by the capacity of the grate to burn fuel. Efficiency of draughting has also been improved, enabling the orifice discharge pressures to be reduced to one-third of the former value. Trials have shown that the modification has effected a 7 per cent saving in coal consumption

The "Merchant Navy" locomotive No. 35018 (below) is the first of thirty locomotives of this class which are being modified to increase their availability, performance and efficiency in service. Amongst other things, they are fitted with a new inside cylinder, three independent sets of Walschaerts valve gear, screw reversing gear, a new smokebox and orthodox boiler cladding plates. The boiler working pressure has been reduced from 280 lb to 250 lb per square inch, and the tractive effort is now 33,495 lb, compared with 37,500 lb before

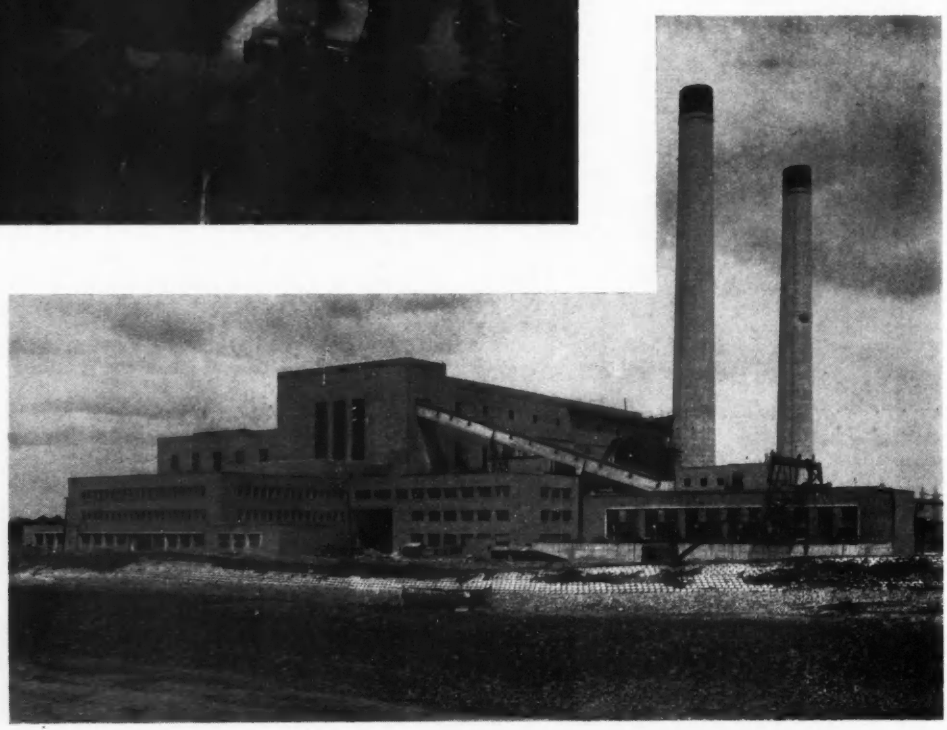


CENTRAL ELECTRICITY AUTHORITY'S POWER STATIONS



The three power stations at Hams Hall, Birmingham, in the Midlands Division of the Central Electricity Authority, constitute one of the largest concentrations of power generation in Great Britain. They represent a steady development over a period of about thirty years. Together they will eventually have an installed capacity of nearly 1000MW, of which 360MW will be in the new station, Hams Hall "C," which will be connected to the 275kV supergrid. Of the six 60MW turbo-generator sets to be installed in the new power station two were commissioned in 1956, and one of these sets can be seen, during erection, in the view of the turbine hall reproduced on the right. Steam will be generated in six 550,000 lb per hour boilers fired with pulverised fuel, and will be supplied to the generators on the unit system at 900 deg. Fah. and 900 lb per square inch. Three cooling towers are being built to handle about 4,000,000 gallons of circulating water per day. Make-up water is available from the River Thame. The coal store will provide for the storage of 200,000 tons and the station is expected to burn about 3000 tons per day

Another new C.E.A. power station is Tilbury "A," which is in the Eastern Division of the Central Electricity Authority and will have an ultimate generating capacity of 360MW from six 60MW sets, taking steam at 900 deg. Fah. and 900 lb per square inch from six unit boilers. Each of these boilers is designed for firing either by pulverised fuel or by fuel oil. At present two of the boilers and two of the turbo-generators are installed and the illustration on the left shows the turbine room with erection work in progress. The turbo-generators will run at 3000 r.p.m. and generate at 11·8kV and each machine will be solidly connected to a generator transformer stepping up the voltage to 132kV for switching



Dual-purpose, triple-effect evaporating plants supply 21,000 lb per hour of distillate to each of the first two turbines in Tilbury "A" power station. Two double-effect low-pressure salt-water evaporators will provide the same quantity of distillate for each of the remaining four turbines. Soft water is obtained from a hydrogen-ion sodium blend water softening plant having a continuous output of 5000 gallons per hour. Circulating water taken from the River Thames is handled by six vertical spindle pumps, each with a discharge capacity of 42,000 gallons per minute. Coal is reclaimed by a travelling bridge transporter with a span of 275ft straddling the 60,000-ton coal store. A general impression of the station is given in the accompanying illustration

Fig. 4—The inside of a Calder Hall heat exchanger during tubing. Note the standard of cleanliness

used on site will have to be carried back to the rolling mills for testing the plate for the pressure vessels. In fact, no standards can be taken for granted.

In all, 1956 has been an historic year for Britain in the advance towards obtaining economic power from nuclear fission. The future is an exciting one for the nuclear scientists and engineers. The peaceful use of atomic energy is no longer a hope of the future, but is before us to-day. Yet world events have still not allowed nuclear fission to shed its destructive shadow and during the year the United Kingdom carried out the third and fourth series of weapon tests at Montebello and at the new Maralinga range.

Electrical Engineering in 1956

No. I

PROPOSALS for reorganising the electricity supply industry in England and Wales were detailed in a White Paper* published last November, when a Bill was introduced to Parliament to give effect to those proposals. It will be recalled that the present organisation of the supply industry as laid down in the Electricity Act of 1947, consists of a Central Electricity Authority appointed by the Minister of Fuel and Power to develop and maintain the electricity system and of twelve area boards. Electricity is generated by the central authority and is delivered in bulk to the area boards. Subject to general control of policy by the central authority, each of the area boards is responsible for the distribution of electricity to consumers within its area. To protect consumer interests the Minister appoints a consultative council for the consumers served by each of the area boards.

In 1954, after the system outlined above had been in operation for about six years, the Government set up a committee, with Sir Edwin Herbert as chairman, " to inquire into the organisation and efficiency of the electricity supply industry in England and Wales in the light of its working under the Electricity Act, 1947, and to make recommendations." In its report, which was published in February, 1956,† the committee acknowledged the very real achievements of the industry since vesting day, but expressed the view that its organisation was capable of considerable improvement. In particular the report was critical of the fact that the central authority combined the dual functions of supervising the general policy of the industry and of generating electricity in bulk ; this combination of functions led to undue concentration of responsibility at the centre and saddled the senior executives of the central authority with an excessive burden of routine work.

Reorganisation Proposals for Electricity Supply Industry

As stated in the White Paper, the Government believes that the Herbert Committee has shown the existence of a defect in the structure of the industry and considers that " reorganisation in the light of the committee's findings is made all the more necessary by the industry's new responsibility for the nuclear power programme." Accordingly the Government accepts the committee's recommendation that the functions of generating and delivering electricity in bulk should be separated from the functions of co-ordinating and controlling the whole system of generation and distribution, and that the former functions should be discharged by a new Central Electricity Generating Board appointed by the Minister.

The Government also accepts the committee's recommendation that the area boards should have greater autonomy. By the Electricity Act, 1947, the central authority and the area boards were required to operate so that their combined revenues sufficed to meet their combined outgoings on revenue account " taking one year with another." Now, " to encourage financial responsibility and a critical attitude to costs," the Government considers that the generating board and each area board should be required by law to balance their accounts individually. It is proposed, in line with the Herbert Committee's recommendation, to wind up the industry's central reserve fund and to distribute the proceeds to the boards, each of which will then be required to maintain its own reserve fund. The Government also agrees with the committee that the Minister should no longer be obliged to consult the central authority before making appointments to the area boards.

On the question of the organisation at the centre, however, the Government does not accept the Herbert Committee's recommendation that the present C.E.A. should be replaced by a new central authority which would consist of members independent of the area boards and would have wide powers of supervision over the industry, without exercising any executive functions. Those powers would include policy approval of development programmes, capital and revenue budgets and bulk supply and retail tariffs. The Government, on the other hand, concludes that if the individual boards are to bear ultimate responsibility for their own well-being, then co-ordination between them can best be achieved, not through a central authority with powers of direction and control, but through a new body whereby both the generating and distributing sides of the industry can resolve their common problems under independent guidance.

Accordingly it is proposed to establish an Electricity Council, having a chairman and one or two deputy chairmen appointed by the Minister ; the other members of the council will be the chairman and one other representative of the generating board and the twelve chairmen of the area boards. The task of this council will be to promote the efficient operation of the generating board and area boards as parts of a co-ordinated system of electricity supply ; to act as agent for those services that are best conducted in common, such as major research projects and the raising of finance ; and to advise the Minister on matters affecting the industry. Although each board will bear ultimate responsibility for the proposals that it puts to the Minister, the boards will be required to submit their plans first to the electricity council.

The main functions of the Minister in relation to the reorganised industry will be to appoint the chairman and deputy chairman of the electricity council and the members of the boards ; to approve the industry's research programme and the capital development plans of each board, and the associated borrowing requirements. The Minister will also be empowered to issue general directions to the council and the boards if he considers them necessary in the national interest.

In Scotland, where the electricity supply industry was reorganised in 1955, there are two Scottish electricity boards which are independent, each being responsible for both generation and distribution in its own area. This structure will not be directly affected by the changes proposed for England and Wales.

Generation Capacity

The electricity supply industry, which is to be reorganised on the lines indicated above, is growing so rapidly that its size is doubled every ten years or so. In the year ended March 31, 1956, for example, the C.E.A. power stations generated over 75,500 million units of electricity (an increase of 9·4 per cent over the preceding year) and in the same period new generating plant was commissioned in thirty-seven power stations and yielded an increase of 1632MW in the output capacity of the C.E.A. system. New generating plant commissioned in the calendar year 1956 totalled 1937MW (including 140MW in stations owned by the South of Scotland Electricity Board), 12½ per cent more than was commissioned in 1955.

An important adjunct to the generating

* *Proposals for the Reorganisation of the Electricity Supply Industry* (Cmnd. 27). H.M. Stationery Office.

† *Report of the Committee of Inquiry into the Electricity Supply Industry.* H.M. Stationery Office.

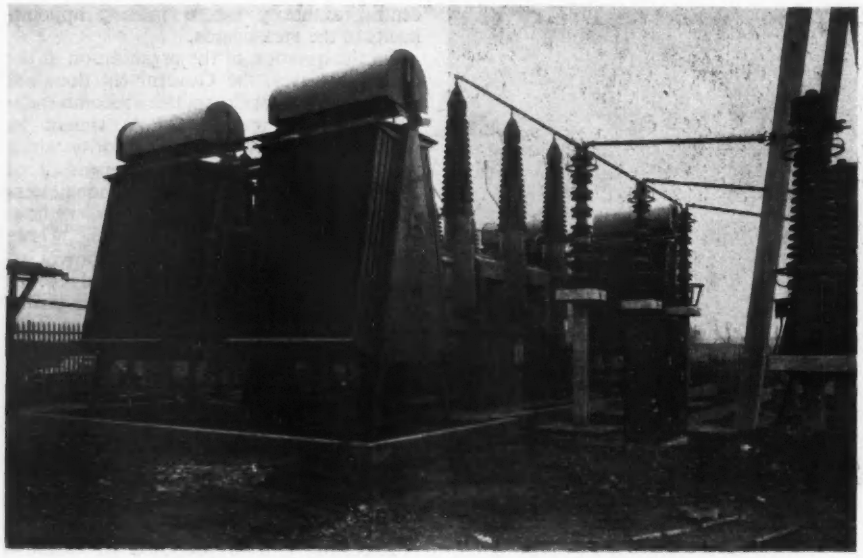


Fig. 1—120MVA three-winding transformer, for 275/66kV, installed at the Blyth substation of the Central Electricity Authority

capacity of the C.E.A. system is the 275kV super-grid which is to provide the main interconnection between generating centres, particularly between the north, midlands and south. During the year under review the total length of 275kV lines working at 275kV (or initially at 132kV), or under construction, was 1500 miles. Among the sections that were completed and taken into service were one of 47 miles of double circuit line between Staythorpe (Newark) and Drakelow (Burton-on-Trent), and another of 109 miles between Staythorpe and Elstree. The sections that became operational, initially at 132kV, included one circuit of 46 miles between Elstree and Tilbury and another of 19 miles between Drakelow and Hams Hall, near Birmingham.

A typical 275kV installation is shown in Fig. 1, which illustrates a Parsons 120MVA three-winding transformer for 275/66kV on site at Blyth substation of the C.E.A.

Examples of current power station plant commissioned during 1956 are also illustrated herewith. In Fig. 2 we show the first single-axis 100MW, 3000 r.p.m. generating set in Great Britain. It is installed at Castle Donington power station and it consists of a Metropolitan-Vickers two-cylinder, tandem-compound turbine driving a 13·8kV hydrogen cooled generator. It is the first of six such sets, each of which will be supplied with steam at 1060 deg. Fah. and 1600 lb per square inch from a pulverised fuel-fired Babcock and Wilcox boiler generating 830,000 lb of steam per hour. Cooling water will be taken from the River Trent, the effect being augmented by four cooling towers, each handling 4,500,000 gallons of water per hour. The station output will be stepped up from 13·8kV and connected to the 132kV and 275kV systems.

Two other new power stations of 1956, Hams Hall "C" and Tilbury "A," are illustrated on Plate 8, facing page 9. Two of the six G.E.C. 60MW hydrogen-cooled sets to be installed in Hams Hall "C" were commissioned during the year, together with two Simon-Carves 550,000 lb per hour pulverised fuel-fired boilers. In Tilbury "A" power station the plant commissioned in 1956 included two English Electric 60MW turbo-generators and two John Thompson pulverised fuel-fired boilers, each having a capacity of 540,000 lb of steam per hour.

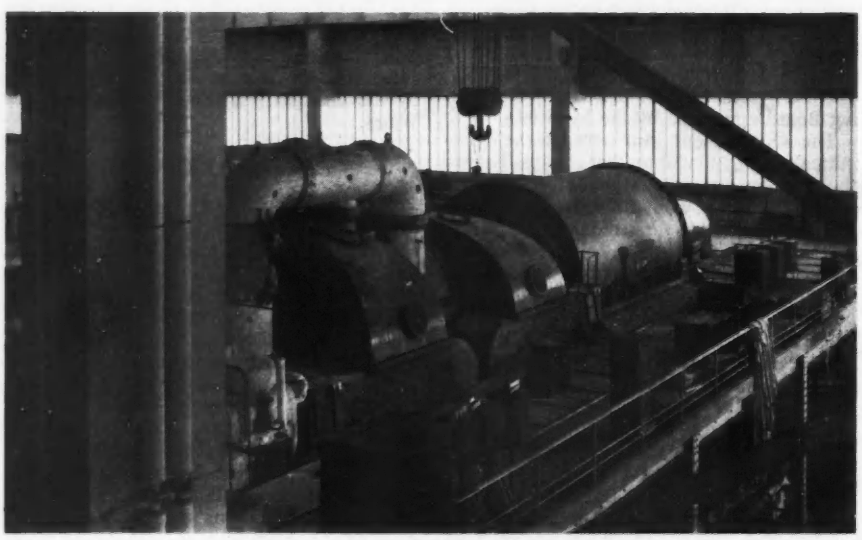


Fig. 2—The first 100MW, 3000 r.p.m. single-axis generating set in Great Britain is installed at Castle Donington. It is a two-cylinder tandem-compound turbine driving a 13·8kV hydrogen-cooled generator

Technical Developments in Electricity Supply

In the article reviewing nuclear developments on page 5 of this issue, reference is made to this country's nuclear power station programme. To implement the first stage in this programme, the C.E.A. placed contracts in December with the Nuclear Power Plant Company, Ltd., for a 360MW station at Bradwell-on-Sea, Essex, and with the A.E.I.-John Thompson Nuclear Energy Company, Ltd., for a 275MW station at Berkeley, Gloucestershire. At the same time the South of Scotland Electricity Board placed a contract with the G.E.C.–Simon-Carves Atomic Energy Group for a 360MW station to be built in Scotland. In the meantime, the C.E.A. was in negotiation with the English Electric–Babcock and Wilcox–Taylor Woodrow group of companies for the construction of the third C.E.A. nuclear power station, which, subject to site approval, is to be built in Somerset.

With these commitments already entered into, the Central Electricity Authority assumes a pre-eminent position in the development of nuclear power on a commercial scale. These projects involve a greater element of commercial risk than would normally be acceptable to a large public utility which is under a statutory obligation to balance its revenue account. That risk is undertaken because of the urgent need to find sources of non-fossil fuel. The risk is doubly worthwhile because of the potential rewards to be won in export markets by British companies which, with the backing of the U.K. Atomic Energy Authority and the C.E.A., will be the first to acquire engineering "know-how" needed to build nuclear power stations that may be relied upon for electricity generation on a commercial basis.

When viewed alongside the nuclear power programme other technical developments fostered by the Central Electricity Authority appear over-shadowed, but are no less important, particularly those that are directed towards higher thermal efficiency and fuel conservation. The trend toward larger generating sets, for example, is gathering momentum. Thus, the plant programme for 1961 which was approved by the Authority during the year under review includes five units of 200MW, six of 120MW, one of 100MW and only four of 60MW. Besides the development of the 200MW sets for High Marnham, near Tuxford, which continued during the year, work was started on the outline design of two other proposed stations with 200MW sets, one at West Thurrock on the Thames estuary and the other at Willington (near Derby), which will adjoin the Willington "A" station and, like it, will be of semi-outdoor design similar to Ince station, near Ellesmere Port.

Since the maximum economy is likely to be obtained from nuclear power plants by operating them for supplying base load, it is considered desirable that new installations of conventionally-fired steam plants should be suitable for two-shift operation. These requirements have been specified by the C.E.A. in terms of the transient conditions to be met during starting up and the rates of loading, and they are being met to a large extent in the later designs of steam turbines for the 200MW sets mentioned above. Provision is also being made for the maintenance of continuous output when required, and the later 200MW machines will incorporate facilities whereby it will be possible to check the performance of the

turbine protective equipment without taking the sets off load.

In the design of boilers for the 200MW generating sets attention is being given to the problems of maintaining adequate steam temperatures when the steam requirements of the turbine are low; and of devising some form of variable-speed drive for the boiler feed pumps to minimise wear and tear on the feed water regulating valves under starting-up conditions. Operational experience is to be obtained on a full-size prototype hydraulic coupling installed in an existing station. There is evidence that natural circulation in the boilers will be practicable at the rated steam outlet pressure of 2450 lb per square inch gauge.‡

Recent developments also show that 120MW reheat sets can be made sufficiently flexible in their operation to be suitable for two-shift working. Future plant programmes have been revised accordingly so that 120MW sets will be installed instead of 60MW sets where practicable, with the object of exploiting the lower capital and operating costs of the larger sets. Twenty-six 60MW sets which were to have been installed in five power stations will, therefore, be displaced by thirteen 120MW sets. Thus, at Rugeley power station on the Trent two 120MW sets will be installed instead of the four 60MW sets originally authorised in July, 1955. The other stations involved in the revised programmes are Staythorpe "B," Skelton Grange "B," Uskmouth "B," and Belvedere.

The C.E.A. is investigating a new thermodynamic cycle and in this connection the Authority's report for 1955–56 stated that work went ahead on the installation of a superheater test rig at Littlebrook power station, Dartford, Kent. Briefly, this equipment consists of a superheater element heated by the combustion of pulverised coal. Steam at 200 lb per square inch is heated in the superheater from 965 deg. Fah. to 1400 deg. Fah. The combustion air for this rig is preheated regeneratively and enters the burners at about 1600 deg. Fah. The characteristics of this superheater element are being investigated as a prelude to the design of a complete assembly for studying the cycle.

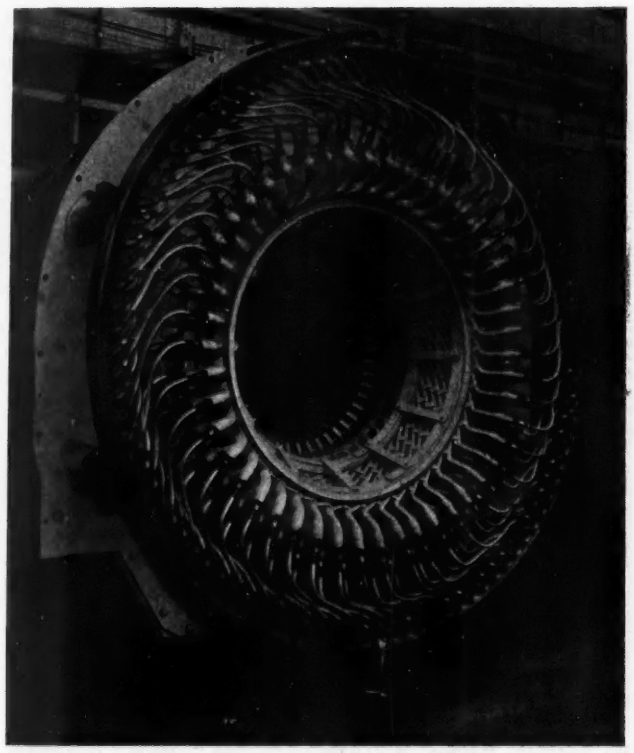


Fig. 3—Partially completed water cooled stator of 30MW generator. This view shows the water header and the tubular plastics end connections at one end of the stator

A good deal of attention is being devoted to methods of cooling large turbo-generators. The machine for the first High Marnham set will have both stator and rotor conductors cooled internally by hydrogen. But for other 200MW generators methods of applying liquid cooling to the stator windings have been devised. Because of weight and loading gauge restrictions, liquid cooling is likely to be necessary to keep down the size of sets above 200MW output, such as the 275MW single shaft and 550MW twin shaft cross compound sets now envisaged by the C.E.A.

To obtain experience of liquid cooling by direct contact with stator conductors the C.E.A. has made arrangements whereby certain smaller sets already under contract will incorporate this kind of cooling. One such generator has already been installed at Bold (St. Helens) power station, in the Merseyside and North Wales division of the C.E.A. It is a 30MW, 11·8kV, 3000 r.p.m., a.c. generator, made by Metropolitan-Vickers Electrical Company, Ltd., and it has been supplied instead of one of the four Metropolitan-Vickers air-cooled machines on order for Bold power station. Two of the air-cooled machines have already been commissioned. Apart from its water-cooled stator winding the third generator (Figs. 3 and 4) is an exact duplicate of the air-cooled machines, the windings having been designed to fit the same size of stator core and slots. The conductor, however, consists of twelve hollow strands (as described in our issue of December 14, 1956, page 854), through which cooling water is circulated. The cooling water is circulated via an inlet manifold at one end of the stator frame, through the hollow stator conductors in parallel, to an outlet manifold at the other end of the stator. The connection between the water manifolds and each of the coil ends is made by a length of plastics tubing, the end of which is gripped between a stainless steel insert and a copper ferrule to form a watertight joint.

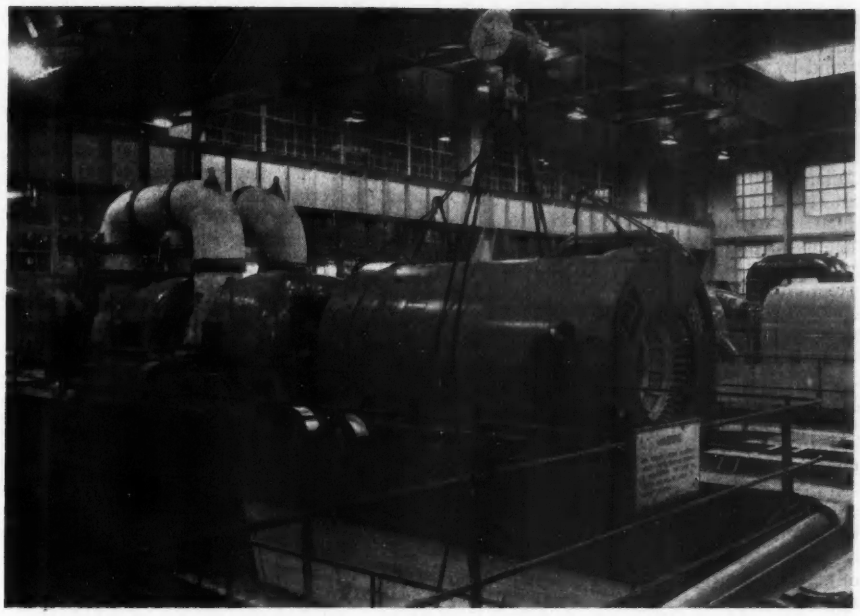


Fig. 4—Water cooling is used for the stator windings of the third 30MW, 3000 r.p.m. generating set to be installed at Bold power station. In other respects the third set is a duplicate of the first two sets

Distilled water is pumped through a closed circuit which includes the winding and a filter, cooler conductivity recorder, flow alarm, temperature alarm and level switch leak detector. Standard works tests were carried out using distilled water with a conductivity of 2·5 reciprocal megohms per cubic centimetre. At 37·5MVA, zero power factor, the maximum temperature rise of the distilled water was only 2 deg. Cent. and the copper temperature rise exceeded this value by only 0·2 deg. Cent. After a five-hour temperature run with a current of 1750A the copper temperature rise was only 29·2 deg. Cent. The corresponding temperature rise on one of the existing 30MW air-cooled machines at Bold would be about 115 deg. Cent. with a current loading of 1835A. The load-carrying capacity of the stator winding is therefore increased very substantially by water cooling, and these advantages would be of even greater significance in machines with ratings of 200MW and more.

Submarine Power Cables

Two interesting developments in power transmission by submarine cable deserve notice. The first was the inauguration in

‡ Annual Report of the Central Electricity Authority. October, 1956.

September, 1956, of bulk electricity supply from the Canadian mainland to Vancouver Island by a new power link, the main part of which consists of 91 miles of single-core, gas-filled, 138kV cable, described in our issue of October 26. This cable, which was made and laid by the British Insulated Callender's Cables group of companies, consists of two layers of copper wires (0·35 square inch) and a conducting screen of three metallised paper tapes laid over a central, hollow, spiral steel duct. Pre-impregnated paper tapes applied over the metallised paper screen form the dielectric, which is itself screened with copper tape. A lead-alloy sheath is extruded to a shrink fit over this core and is reinforced against the internal gas pressure (in this instance, 300 lb per square inch) by three layers of tin-coated bronze tape applied in the same direction. Between this tape and the jute yarn bedding for the armouring is a protective sheath of vulcanised rubber designed to withstand the highest lead sheath voltages liable to occur in service. The armouring is a single layer of galvanised steel wire applied in a direction opposite to that of the reinforcing tapes to balance the torsional forces. The armouring is served with two layers of compounded jute yarn, giving the cable an overall diameter of about 4in.

The second event in submarine power transmission was the announcement by the Central Electricity Authority and Electricité de France that they proposed to go ahead with a cross-channel cable connection between the electricity systems of the two countries. The link is to be a single cable (with a sea return) capable of transmitting 120MW to 150MW at 200kV, using direct current instead of alternating current as was originally envisaged, which would have involved four cables allowing one in reserve. The fact that the much more economical direct current system is now considered feasible for the cross-channel scheme is largely due to the success in 1955 of the 100kV power link between Sweden and the island of Gotland and to recent progress in the development of high-power mercury-vapour mutators. Work on the cross-channel link is expected to begin early this year and should be completed in 1960 at a cost of about £4,000,000.

(To be continued)

The Royal Navy, 1956

BY OUR NAVAL CORRESPONDENT

No. I

British Defence Policy

THE chief aims of the present British defence policy are to maintain the deterrent and to keep the Services ready to deal with the cold and limited war. Before making an assessment of our naval strength in this review, it would be well to consider whether any modification of these aims is required in the light of the recent emergency in the Middle East. There is good reason for believing that this country and the rest of the free world would have been less divided had the British and French forces intervened in the very early stages to uphold the international status of the Suez Canal. But they certainly would not have been ready at that time to intervene with overwhelming force, thus ensuring the minimum number of casualties on both sides. Moreover, should we again have to take police measures pending action by the United Nations, we may not be fortunate in having a convenient base and a relatively weak opponent. Finally, the United States, while emphasising dislike of the use of armed force except in self-defence, clearly indicated, by her warning to Russia to keep out of Egypt, that she continues to act as an effective deterrent against global war. Should we not therefore place more emphasis on the readiness of the Services for the cold and limited war and less on adding to an already adequate deterrent ? We must, however, also provide for the possibility of the deterrent failing, which, in the interests of N.A.T.O., requires the survival of Britain as a base of operations. It is, in fact, clear that future British defence programmes should aim to provide the kind of forces and defences which will not only best ensure the survival of Britain, but will enable the Services to be instantly ready to safeguard our wide interests in a local or limited war. An essential part of these forces is a strong navy. The Royal Navy must have an adequate number of modern ships and aircraft to co-operate effectively with troops in a local war. In a global war it must be strong enough to safeguard the imports necessary for our survival. Russia will shortly have 30 powerful modern cruisers, many with 7in guns ; 150 destroyers ; 500 submarines, of which 300 will be capable of operating overseas, and 4000 naval aircraft. The Royal Navy would not, of course, stand alone, but would form part of a closely knit alliance of N.A.T.O. Powers, whose combined navies have a great superiority. But it is well to remember that United States cruisers would have many commitments in the Pacific and Western Atlantic ; that United States carriers would be very occupied in strategical bombing, and that we may expect a clamour for a concentration of United States warships in their home waters if hostile submarines and raiders appear in American waters. It is therefore mainly in relation to the vital task of safeguarding our imports that the strength of the Royal Navy is discussed in the following paragraphs.

Battleships

The Royal Navy still retains the five battleships completed during and since the war. There seems no good reason for dispensing with these ships until we possess ships of cruiser type capable of taking on a " Sverdlov " class cruiser. The " Vanguard " is maintained, at a cost of £700,000 a year, in operational reserve, which means she can be sent to sea quickly in any kind of warfare, global or limited. The remaining four—" King George V " class—are maintained in mothball reserve in the Gareloch, at a total cost of £46,000 a year, most of which is being spent on the " George V " herself. If all four were to be dehumidified and effectively maintained in their present condition, there would be an additional cost of £375,000. To bring all these four ships to a state of readiness would cost about £4,000,000, but the cost of modernising them would be very high indeed. On the other hand, there are almost insuperable difficulties in berthing them in Australia or other Dominions, where they would be reasonably safe from bombing, and it may well be decided to scrap them when we have built a squadron of modern cruisers. But there is no question of scrapping the " Vanguard."

Aircraft Carriers

The size of a carrier required for operations with the fleet is determined by the speed, accommodation and handling facilities she needs to operate the latest types of aircraft used in naval operations. There is now, however, much less need for very fast carriers than during the years immediately after the war. The steam operated catapult—a British design—is capable of launching the heaviest carrier-based aircraft in use by any navy—including the medium-range bombers of the United States Navy. The possibility of reducing landing-on speeds by propulsive jet deflection, the use of the jet flap and in other ways is now under investigation. The angled deck—another British innovation—has greatly reduced the need for a parking ground, and, together with the mirror landing sight, has considerably reduced the time taken for landing-on operations. It is thus possible for the carriers of the Royal Navy—which have to operate only fighters, strike aircraft

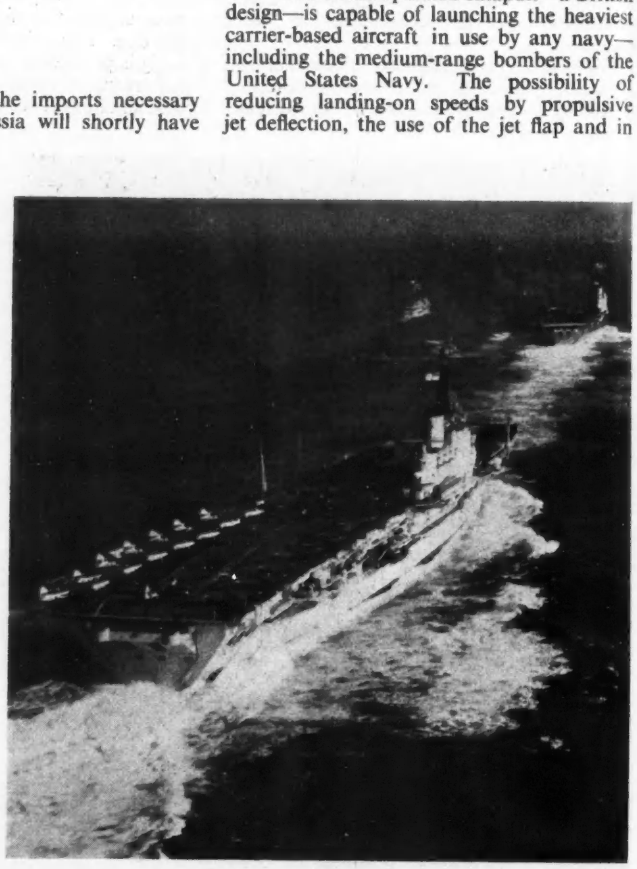


Fig. 1—H.M.S. " Albion," a 22,000-ton, 29½ knot " Centaur " class carrier completed in 1954

and anti-submarine aircraft—to be of relatively small size. We are, in fact, unlikely ever again to require to build carriers larger than the "Centaur" (Fig. 1) class, 30-knot vessels, whose original displacement of 18,000 tons has now been increased to 22,000. With the "Hermes" (still completing) the Royal Navy will have four of these ships, which, with the 36,800-ton "Eagle" and "Ark Royal" and the reconstructed pre-war-designed "Victorious," will provide us with seven fast carriers. When all have been fitted with steam-operated catapults and the angled deck, they will be capable of operating the latest types of naval aircraft, including the "N.113" and "D.H.110" now on the horizon.

It seems likely that the Navy will have to be content with these seven relatively modern carriers for some years to come. For the Fird Lord announced in the current year's Navy Estimates that the "Warrior" is now being fitted with an angled deck and that other carriers will be brought up to date in their turn. The "Warrior" is one of the four remaining 13,000-ton, 24½-knot carriers laid down during the war, when the building programme had to be concentrated on anti-submarine vessels. When modernised, these vessels, like the 15,700-ton Royal Australian Navy's "Melbourne" and the Royal Canadian Navy's "Bonaventure," will be capable of operating earlier jet fighters and anti-submarine aircraft. Two other 15,700-ton carriers have remained laid up and half completed since 1946. There are also still two fleet carriers of pre-war design, the "Illustrious" and "Indefatigable," in reserve, which are of little fighting value and are likely soon to be scrapped. For a limited war the seven fast and four slow carriers now—or shortly to be—available should be sufficient, though if the hostile forces are equipped with the latest types of jet aircraft the latter will not be able to co-operate with our troops ashore as they did so effectively in the Korean campaign. For global war these slow ships cannot operate effectively with 30-knot cruisers as a "battle group" for the protection of the sea communications. There is thus little hope of being able to spare any carriers "to contribute"—in the words of the 1955 Defence White Paper—"to the allied striking fleet . . . which will hit the enemy either independently or in support of allied land forces."

Fig. 3—H.M.S. "Apollo," 2650 tons. A 40 knot minelayer completed in 1944

Ships of Cruiser Type

With the transfer of the "Royalist" to the Royal New Zealand Navy, and of the "Diadem" to the Pakistan Navy, the Royal Navy is now left with only twenty cruisers. All but four of them are of pre-war design and four have nearly reached their normal life of twenty years (Fig. 2). Since the failure of the Moscow Conference, when it became clear that the Soviets were not going to co-operate with the Western nations, we have waited year after year on research and development for the green light to lay down a fighting ship larger than a frigate. Latterly, in view of the development of the guided missile, aircraft with supersonic speed and the small nuclear bomb, the Admiralty has not pressed for a building programme pending the production of a ship-to-air guided missile. There is, indeed, justification for this decision, since the anti-aircraft gun now provides no protection except against low-flying aircraft. None the less, for trade

Fig. 2—H.M.S. "Birmingham," a 9100-ton, 32·5 knot cruiser completed in 1937, since reconstructed and modernised

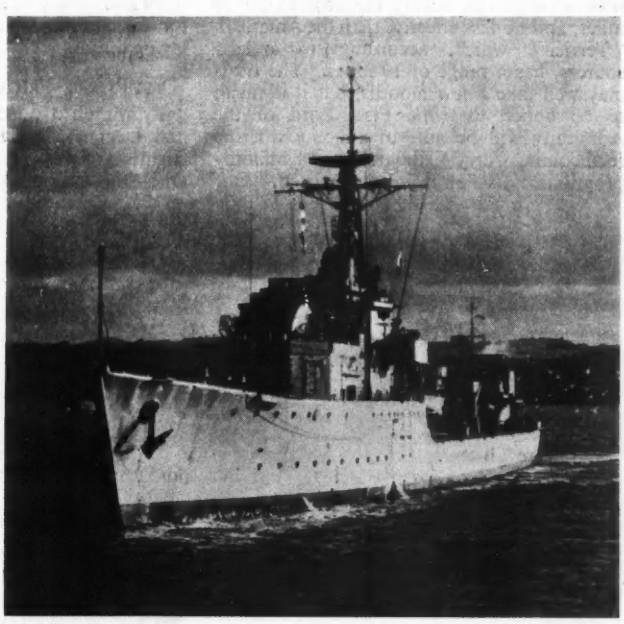


Fig. 4—H.M.S. "Tenacious." One of the seven "T" class, 1730-ton destroyers converted for duty as a fast A/S frigate

Fig. 5—H.M.S. "Coniston," a 340-ton, twin-screw, 15-knot coastal minesweeper

protection and control, and for escorting and all other duties likely to be required of a cruiser, the radar-controlled gun remains the most effective weapon as her main armament. The Admiralty is thus to be commended for deciding, in the face of considerable opposition, to complete the three cruisers of the "Tiger" class, which were laid up half completed for several years after the war. With their four radar-controlled 6in guns of a new type with a very high rate of fire they will at least provide us with ships, apart from the battleship "Vanguard," which can take on a cruiser of the "Sverdlov" class on equal terms. It is disappointing that the United States Navy is so far ahead of us in guided missile development. Already three United States cruisers have been converted for firing a ship-to-air guided missile which has been in quantity production for the past two years. Still more cruisers and several destroyers and frigates are being similarly converted, and various types of ships are now being laid down with a guided missile anti-aircraft armament. Britain has at last produced a ship-to-air missile for the Fleet, and it is now being given sea trials in the reconstructed maintenance vessel H.M.S. "Girdle Ness." It promises to be a first-rate missile, with a range unofficially reported to be 20 miles, and no less effective than the American "Terrier" which, according to official sources, has a range of 10 miles. The trials may well take a few months, but it is much to be hoped that the First Lord of the Admiralty will be able to announce in the forthcoming Navy Estimates that a building programme has at last been started. Our twenty cruisers are aged and war weary and the nation must not be put off with one prototype vessel. The minimum and urgent requirement is a squadron of four ships of cruiser type.

In assessing the strength of our cruiser force it would be wrong to exclude the eight "Daring" class ships. Designed during the war and laid down soon after its conclusion, these vessels might well be regarded as light cruisers—if we had such a category. They were built as destroyer leaders of 2600 tons; with their powerful gun armament of six 4·5in guns in twin turrets, with ten 21in torpedo tubes for attacking heavy ships, and with a speed of nearly 35 knots, they are the most comprehensive type of light warship ever built. Provision has been made for four more, but improved, vessels of this type—two in the previous, two in the current, year's Estimates. But all these new vessels are to be designed with a guided missile anti-aircraft armament and it seems doubtful if any of them will be laid down before the "Girdleness" has completed her trials. Reference must also be made to our three 40-knot minelayers (Fig. 3). With a displacement about the same as the "Daring" class, an armament of four to six 4in guns and a speed of 40 knots, they might well be used as escorts for Task Forces when not required for minelaying duties.

Destroyers, Frigates and Lesser Craft

By March 31, 1956, thirty-one destroyers had been converted to fast anti-submarine frigates and two more were in hand (Fig. 4). One—the "Wrangler"—has recently been transferred to the South African Navy. Originally forty-five were earmarked for conversion under the 1951 rearmament programme, but the First Lord stated nearly a year ago that the programme of conversion to anti-submarine frigates was then virtually complete. It may well be that some of the further fourteen vessels originally earmarked are to be converted to aircraft direction frigates. In any event, if the original programme is adhered to, the Royal Navy, since the recent sale of four destroyers to Pakistan, will be left with only fifty-eight destroyers—apart from the "Daring" class ships—compared with the 150 powerful modern vessels of this type in the Soviet Navy. The various types of modern fast frigates, some of them with a powerful gun and torpedo armament, will no doubt take over more and more of the "maid-of-all-work" duties of the destroyer. One recalls in this connection that three or four years ago a member of the Board of Admiralty expressed the view that the "Daring" class were the last vessels of this type we were likely to build. But with the Soviet Navy still increasing its number of destroyers, it is clear that we cannot stand still. Indeed, the four new fleet escorts to be laid down are to embody "all the newest developments in the destroyer field." Destroyers, except when converted to frigates and fitted with extra fuel tanks, are not suitable vessels for commerce warfare in ocean waters. But with their powerful torpedo armament and "homing" torpedoes they offer a serious menace in dark hours to a Task Force of carriers and cruisers.

The frigates and lesser craft authorised under the 1951 rearmament, and described in these columns a year ago, are now coming into service in large numbers. Of the eighteen anti-submarine frigates ordered, seven had been completed by September, 1956, leaving eleven still under construction (in addition to one building for India). Six are very fast vessels and armed with two 4·5in guns. The remaining twelve have only one shaft, but all eighteen are equipped with a novel design of geared steam turbines of high power. One aircraft direction frigate armed with two 4·5in guns has also been recently completed, and four more are building. Fitted with radar search and direction equipment, these vessels will be used to give early warning of enemy aircraft, either to a Task Force or to a convoy. Finally, there are five anti-aircraft frigates under construction, with a powerful armament of four 4·5in guns in two twin turrets. All these ten ships will have Admiralty standard Range 1 diesel engines. Five more frigates were authorised in the 1955–56 Navy

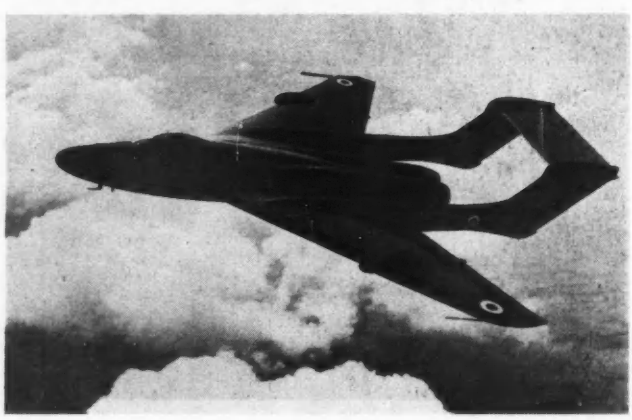


Fig. 6—The "DH 110," the Navy's future all-weather interceptor fighter

Fig. 7—The Supermarine "N.113," twin-jet future naval fighter, on its initial deck landing trials in H.M.S. "Ark Royal"

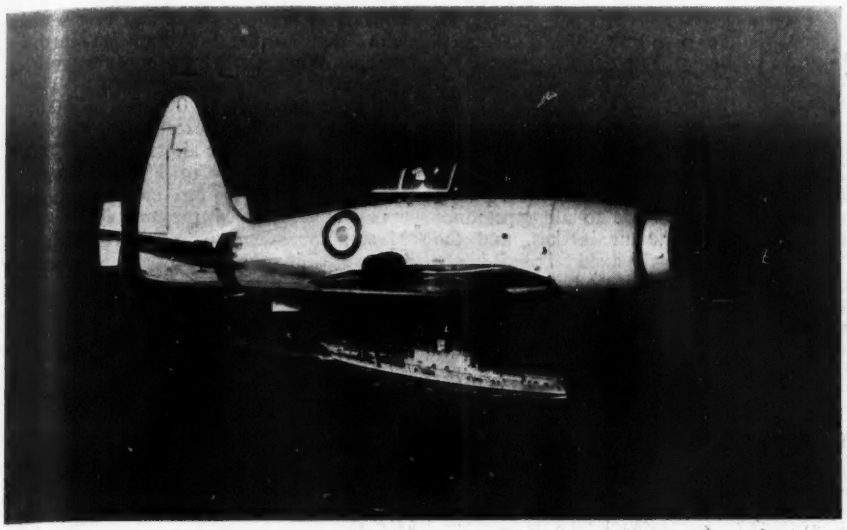


Fig. 8—The "Wyvern," the Navy's only existing strike fighter

Estimates and a further three in the current Estimates, but they are to be general purpose vessels without any specialised role. Over 160 of our 19-knot wartime frigates are still in service, but only seven of them have been modernised and many of the remainder will soon be sold or scrapped in accordance with the present policy of reducing the number of ships in reserve. Apart from some sixty wartime ocean-going minesweepers, seventy-five coastal minesweepers (Fig. 5) and seventy-five inshore minesweepers, all of a new type for dealing with magnetic and acoustic mines, have already been completed and thirty-four of the former and twenty-five of the latter are still under construction. There are also nineteen new fast patrol boats in service with thirteen more building, in addition to fourteen seaward defence vessels built and three more under construction.

The Fleet Air Arm

Two years ago, when presenting the 1955-56 Navy Estimates, the First Lord announced that a replacement had been planned for the "Wyvern" (Fig. 8), the Navy's strike fighter which is underpowered and unsuitable as a carrier of the latest types of missiles. Nothing more has been heard of this new machine. It is likely to be a larger aircraft than the "Wyvern," with a much increased range, but in view of the relatively small size of the British carriers there is no question of our following the United States Navy in building naval aircraft to operate as strategical bombers. British naval aircraft are required primarily for the protection of our sea communications and to provide air cover for allied land forces until shore based aircraft become available, though we may expect the new strike aircraft to be capable of carrying out atom bomb attacks on war potential installations in coastal areas. An important milestone was reached last year in the successful deck landing trials of the Navy's future all-weather interceptor—the de Havilland 110 (Fig. 6)—and the Vickers Supermarine N113 day fighter (Fig. 7). Production orders have been placed for both these aircraft and in a few years they should replace the "Sea Venom" and the "Sea Hawk," respectively. The trials were carried out from the "Ark Royal"—the first of our carriers to be fitted with steam catapults—but the N113 had not been "cleared" for catapult launchings and in this case the trials were restricted to landing and flying off along the deck. This new high-performance strike/fighter, with its twin Rolls-Royce "Avon" engines, has already greatly impressed the pilots who operated it, both at Boscombe and in the carrier, with its performance both as a fighter and a strike aircraft. The landing speed is, however, somewhat higher than the de Havilland 110—also powered by twin Rolls-Royce "Avons"—and future marks will probably be fitted with supercirculation (a device which blows high pressure air over the wing flaps to avoid separation). Since catapulting has eliminated the need for carriers to have high speed for flying off, the reduction in landing-on speeds by supercirculation and other devices now under investigation may well give a new lease of life to our four 24½-knot "Glory" class carriers. Carrier-borne aircraft, it may be noted, played a large share in the successful intervention by British and French forces in the Middle East, and it was entirely due to the preliminary offensive by carrier-borne and shore-based aircraft against the Egyptian Air Force and airfields that paratroops were able to land at Port Said on November 5.

(To be continued)

New Year Honours

The New Year Honours List was published last Tuesday morning. It includes announcement of the following awards which are made to engineers, scientists and others engaged in the engineering and allied industries:

Order of Merit.—Sir John Cockcroft, F.R.S., director of the Atomic Energy Research Establishment, Harwell.

Knights Bachelor.—Dr. D. S. Anderson, director of the Royal College of Science and Technology, Glasgow; Mr. J. N. Dean, chairman, Telegraph Construction and Maintenance Company, Ltd.; Mr. J. Eccles, deputy chairman (operations), Central Electricity Authority; Mr. G. R. Edwards, managing director, aircraft division, Vickers-Armstrongs, Ltd.; Mr. W. L. Owen, director of engineering, United Kingdom Atomic Energy Authority's industrial group; Mr. J. L. Train, M.I.C.E., member of the British Transport Commission; Mr. L. A. G. Hooke, managing director of Amalgamated Wireless (Australasia), Ltd.; Mr. L. H. Martin, Professor of Physics at Melbourne University.

C.B.—Mr. J. F. A. Baker, chief engineer, highways engineering staff, Ministry of Transport and Civil Aviation; Mr. B. K. Blount, deputy secretary, Department of Scientific and Industrial Research; Mr. V. A. G. Lambert, director-general of armaments production, Ministry of Supply; Mr. B. F. Pool, director of Navy Contracts, Admiralty; Mr. R. H. Purcell, chief scientific adviser, Home Office.

K.C.M.G.—Colonel Sir Stanley Angwin, M.I.E.E., chairman, Commonwealth Telecommunications Board.

C.M.G.—Mr. R. J. Halsey, assistant engineer-in-chief, General Post Office; Mr. Kenneth Humpidge, director of Federal Public Works, Nigeria; Mr. E. W. Titterton, Professor of Nuclear Physics, Australian National University, Canberra.

G.C.V.O.—Brigadier-General Sir Harold Hartley, F.R.S., president of the World Power Conference.

G.B.E.—Sir Archibald Forbes, chairman, Iron and Steel Board.

K.B.E.—Sir Christopher Hinton, engineering member of the board of the United Kingdom Atomic Energy Authority.

C.B.E.—Mr. W. G. M. Anderson, director of works, Air Ministry; Mr. Alexander Barclay, Keeper, Science Museum; Mr. Siegfried Cahn, managing director, Goodlass Wall and Lead Industries, Ltd.; Mr. Donald Campbell, for services to speedboat development; Mr. C. M. Cawley, deputy chief scientific officer, Department of Scientific and Industrial Research; Mr. E. L. Champness, managing director, Palmers (Hebburn) Company, Ltd.; Captain Jack Elvish, principal marine superintendent, Clan Line Steamers, Ltd.; Mr. A. A. Fulton, general manager, North of Scotland Hydro-Electric Board; Mr. A. T. Green, British Ceramic Research Association; Captain (E) William Gregson, R.N.R., chairman, Fuel Efficiency Advisory Committee; Mr. H. R. Houston, deputy chief inspector of mines and quarries, Ministry of Fuel and Power; Mr. O. W. Humphreys, director, General Electric Company's Research Laboratories; Mr. Peter Lloyd, deputy director, research and development, National Gas Turbine Establishment; Mr. Robin McAlpine, director, Sir Robert McAlpine and Sons, Ltd.; Mr. J. Martin, managing director and chief designer, Martin-Baker Aircraft Company, Ltd.; Mr. E. J. Powell, county surveyor, Glamorgan, and chairman of the Road Research Board; Mr. W. W. S. Robertson, managing director, W. H. A. Robertson and Co., Ltd., and chairman, Eastern Regional Board for Industry; Mr. E. J. Sturgess, chief engineer, Shell Petroleum Company, Ltd.; Lieut.-Commander J. W. Thornycroft, R.N. ret., managing director, John I. Thornycroft and Co., Ltd., Southampton.

Synchromesh Transmission.—A five-speed gearbox for inputs up to 300 lb ft has been developed by the David Brown Automobile Gearbox Division, Park Works, Huddersfield. All gears are in constant mesh and on the four higher forward speeds synchromesh is provided. The synchronising mechanism is that due to Porsche, described and illustrated in detail on page 407 on September 21 last year. The compactness of the self-energising brakes results in the weight of the box being 350 lb, including a remote control for cab-over-engine installation. The main casing is light alloy, split in the plane of the main and lay shafts. Two versions are available, a direct-top model with four reductions suitable for vehicles up to 20 tons gross, and for faster vehicles a variant with an overdrive of 0·8 to 1 and three widely and evenly spaced reductions giving an almost identical range from first to fifth of 7·81. In both cases the pattern of the gear shift is the conventional one for three selectors, the lay shaft being loaded in all gears on the overdrive box. The prototype box used Porsche components and was tested at the Porsche plant in Germany, but synchromesh parts for production units will be made by David Brown.

Aeronautics in 1956

No. I

THE last year saw few innovations in Great Britain, but further examples of the arduous nature of the development processes of aircraft. One of the few new aircraft to appear was the Vickers Supermarine "544," successor to the "508" and "525" twin-engined fighter projects; it is illustrated on Plate 6. The English Electric "P.1," having not made a second appearance, even in the air, at the S.B.A.C. Flying Display, was ordered in quantity in November. The Bristol "Britannia" did not enter service as planned, due to extinction of the engines in icing conditions; what little is known of this problem is discussed in the corresponding article on "Gas Turbines."

Abroad, great interest must attach to the emergence of the strategic bomber code-named "Bear"; the estimated performance of this machine is quite extraordinary, with a range of 8000 miles and a maximum speed around 640 m.p.h. Four engines of at least 10,000 h.p. drive supersonic contra-props; each may be a tandem pair, but the configuration of the nacelles does not support this idea.

Supersonic Flight

It is now possible to study, at least superficially, a large number of supersonic research aircraft, fighters, and even bombers. It may therefore be worth while to discuss the design principles revealed and examine how far they may meet the needs of the immediate future.

The earliest supersonic aircraft, with the exception of the products of France, with a long history of interest in such deltas as those of Payen, inherited the swept wing planforms of high-subsonic aircraft. There is, of course, good reason for them to do so, since the lifting efficiency of a wing in subsonic flow is markedly better than for any simple supersonic aerofoil, and for a wing swept within the Mach cone the pressure distribution is essentially that in incompressible flow; it may be said that the air approaching any point on the wing is given "warning" of what lies ahead by part of the wing nearer the root. An early example of these principles is the McDonnell "Voodoo," seen in Fig. 1; as a long-range fighter or reconnaissance machine, it can little afford to waste fuel overcoming unnecessary drag in a supersonic pursuit or dash over a target. Other points of interest are the inner panels of the wings, which are to all appearance fine fairings for the air intakes, and the "flying" tailplane—the fixed tailplane is not only inefficient in supersonic flight, but likely to rob the elevators of some or all of their power. A contrast in many ways is the Grumman "Tiger," of Fig. 2; the air intakes here are faired into the fuselage shape, and there are large boundary layer "spoons." Camber-changing devices on the swept trailing edge of a wing lose in effectiveness by much more than the cosine of the angle of sweep, and it appears that in the "Tiger" no division of the span between flaps and ailerons would give a slow enough approach for carrier landings with adequate lateral control. Very long flaps have therefore been used, in conjunction with spoilers, thus at the same time solving the problem of aileron reversal at high speeds which besets wings with their torsional stiffness lessened by sweep. While the design appears far from extreme, the performance is not: a "Tiger" has been timed at 1220 m.p.h. at 40,000ft close to Mach 1·9. An excellent example of the swept wing supersonic aircraft is the Chance Vought "Crusader," in Fig. 3: here an efficient supersonic air entry makes its appearance, designed, presumably, for those Mach numbers at which the after-burner will be in action. The picture also shows the thinness of aerofoil section required for economic flight at high speeds and the resultant narrow-track undercarriage. The most noteworthy feature of the "Crusader" is the variable incidence of the wing, which allows adequate vision for the difficult operation of a carrier landing from a low-drag cockpit enclosure, and also brings the radar and armament bays within easy reach of the deck. While engineering difficulties were experienced with the wing anchorage, the aircraft has approached service to the extent of carrying out pilot training. During the year, a "Crusader" in the U.S. achieved a timed speed in two directions of 1015 m.p.h., Interpolating, maximum speeds and heights attained by manned aeroplanes were also increased during the year by the Bell "X-2," illustrated on Plate 16.

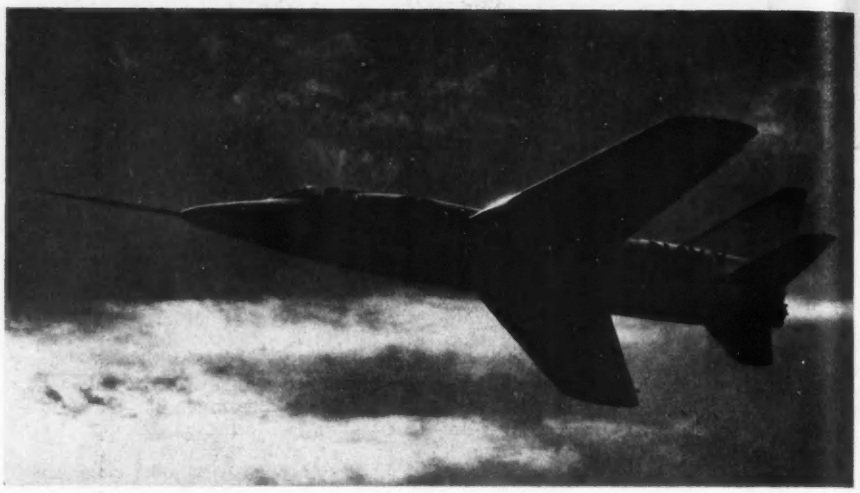


Fig. 2—A Grumman "Tiger" carrier-borne fighter. Noteworthy are the lateral controls, the major part of the trailing edge being occupied by flaps; at high speeds spoilers are used, ailerons at the tips giving control with flaps down; auto-rotation is a shock stalling, not an approach problem. The greater part of the leading edge is also hinged. A "Tiger" this year was brought down by flying into its own shellfire

Fig. 1—The McDonnell "Voodoo," heaviest of single-seat fighters, is seen here in photo-reconnaissance form as the "RF-101A," the cameras travelling in the long, fine nose. Two "J-57" engines with nearly 15,000 lb thrust on reheat give about Mach 1·65, and the range may be extended to 3000 miles by drop tanks. The inner wing panels are dominated by the intakes. Notice the air brakes and the immense incidence range of the tail

The extreme example of the swept-wing design is perhaps the English Electric "P.1." (Plate 6). The ineffectiveness of swept controls has been avoided for the ailerons by laying them across the wing tips, but the flaps have to tolerate sweep. The result is a wing with a resemblance to a delta, but without the large root chord and associated structural efficiency. The problems of the swept wing at low and transonic speeds are also reflected in the design; in the leading edge are to be seen narrow saw cuts that feed high energy air into the boundary layer, and doubtless are intended to prevent it drifting towards the tips. The tendency to instability evidenced by "pitch up," when the heavily loaded tips first feel the effects of compressibility, is corrected by a tailplane low on the fuselage, which gains in effectiveness as it moves away from the wake of the wing. The widely used counter for tip stalling in incompressible flow, washout, is superficially unattractive to deal with compressibility stall, since the indicated air speed at Mach 1 varies from

Fig. 3—The favourable ground angle of the Chance Vought "Crusader" is obtained by a variable incidence wing, allowing full benefit to be derived from the drooped leading edges. This picture shows the supersonic air intake, fixed gun armament and undercarriage retracting into the fuselage. The rear of the body is made of titanium to withstand the heat of the afterburner, and many of the skin panels are cast magnesium

760 m.p.h. at sea level to 420 at 35000ft in the standard atmosphere. However, it is interesting to note that U.S. designers are discussing a distribution of camber along the span which approximates to wash-out, and is intended to appear on supersonic maximum, if not cruising, aircraft. The "P.1," it should be observed, has by no means the wing of extreme sweep, the designs of Mikoyan for such performance being similar, but with less severe sweep on the trailing edge. Thus, it is seen that the delta form is being approached, with a consequent easing of structural problems.

Despite its attractive simplicity, the delta planform has been abandoned for many high-subsonic aircraft, such as the Gloster "Javelin" and the Avro "Vulcan"; just as sweep is ineffective at the root, so its effectiveness is low at the tips, and these aircraft have, therefore, had the leading edges extended and the thickness/chord ratios reduced. Such aircraft as the Chance Vought "Cutlass" and the Douglas "Sky-ray" show that a less tapered shape can be highly successful. For supersonic flight, however, the delta is a widely supported design, its principal merits being that it retains lifting efficiency and avoids centre of pressure travel due to the wing becoming supersonic, without the structural difficulty of a swept wing, and in addition dispenses with the wave drag of a tailplane.

One of the best-known deltas is the Convair "F.102A," illustrated in Fig. 8, and now in service with the U.S.A.F. as an all-weather interceptor. A modern delta from the same manufacturer is the "Hustler," shown on Plate 16; on the bomber the reduced lift curve slope is acknowledged in the use of a large angle of incidence, and camber appears on the fore part of the wing. The distinctive feature of this design is the location of the engines; engines were podded in pairs, or with two of the engines above the wing, but the problems of drag and heating of the under-surface of the wing dictated the present arrangement. It is, of course, possible, according to linear theory, to reduce the drag of the wing and bodies to that of an optimum body of the same frontal area, at a selected speed; however, it must be borne in mind that the resulting area distribution cannot be ideal at other speeds, and that the theory is a simplification of physical reality. (That designers appreciate this latter is clear from the fact that "area rule" modifications are always placed as near as may be to the region where the pressure drag actually occurs, e.g. near the wing roots.) The drag minimised, the problems of lift, stability, landing, and so on remain to be solved, and in the case of the delta, in which the flow over the fore part of the wing is subsonic, the interference between nacelles and wing must obviously be considerable. In the event, the shape of the pylons became highly important. The general question of the disposition of engines is still, obviously, open; a solution of aerodynamic appeal is to place them at the wing tips, but this is only practicable when an individual engine contributes only a small proportion of the total thrust.

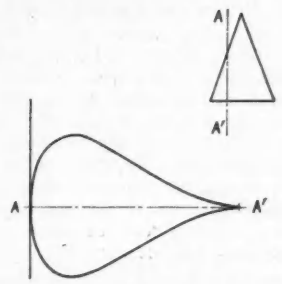


Fig. 6—Optimum section of a delta wing for torsioned stiffness with thin skin construction

Just as with the swept wing, the delta aircraft is often shaped by the low speed case. It might be expected that keeping the leading edge subsonic at all times would yield a dividend in low speed qualities—Fig. 6* shows a section of minimum drag at Mach 2 which would appear, from its blunt leading and sharp trailing edges, to be practical at low speeds, whatever the difficulties of manufacture. In fact, it is found that with thicknesses of a few per cent only, laminar separation invariably occurs at moderate C_L, and there is a school of thought which favours a sharp edge for its, small, improvement in lift curve slope, which is always deficient on swept planforms.

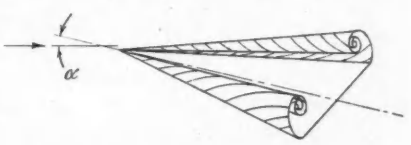
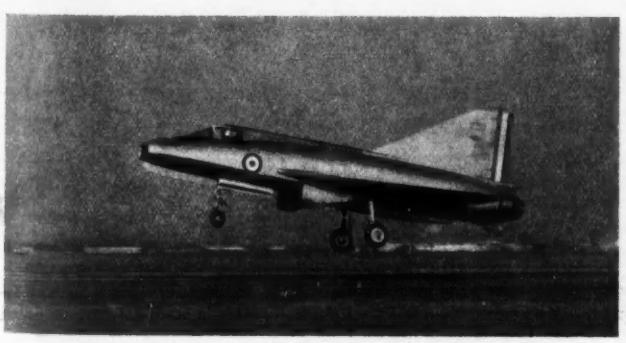
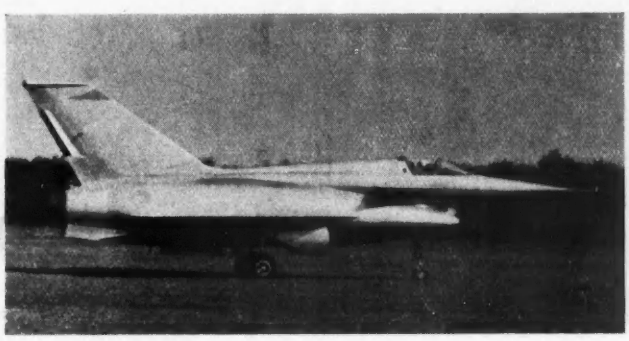


Fig. 7—Flow field over slender delta wing

The phenomena of fully separated flow become important when wings for really fast aircraft are considered. If the leading edge is retained well behind the Mach cone, very low aspect ratios result, and the flow can no longer be visualised in terms of the "lifting line" analogue. In fact, pressure

* T. Nonweiler, "The Design of Wing Sections," *Aircraft Engineering*, July, 1956.





Figs. 4 and 5—Two deltas from France. (Left) The Sud-Est "Durandal" is a target defence interceptor with a supersonic tactical climb: as seen here, it has a rocket motor beneath the fuselage. Note the shallow fins under the front and rear of the fuselage, the immense dorsal fin and the horn balanced ailerons. A simple form of afterburner is used. (Right) The Nord "Griffon" is trimmed by a fore plane distinguishable below the cockpit, unlike its predecessor, the "Gerfaut," which had a small swept moving tailplane high on the fin. Both this and the wing are delta in plan and speeds up to Mach 1·7 are contemplated. The prominence given to the circular air intake is explained by the fact that this aircraft is intended to fly as a ram-jet at speed

changes along the direction of flight become sufficiently small for compressibility to be negligible, a great advantage for the attainment of scale conditions in, say, wind tunnel testing. On a sharp-edged and narrow (20 deg.) delta wing, the flow at angles of attack greater than 3 deg. resembles that of Fig. 7; it can be imagined that the outward drift of the boundary layer on the lower surface will bring it to the leading edge, and, unable to pass round the edge, the layer will separate. P. T. Fink, to whom Fig. 7 is due, has found in the wind tunnel that on a 60 deg. delta whose transverse section is an ellipse of 3 : 1 major : minor axes, this régime exists beyond 10 deg. incidence; although there is no edge to cause a discontinuity, the boundary layer, once it has reached the suction peak above the stagnation point, will encounter a severe adverse pressure gradient. The effect of this vortex field is, as one would hardly dare to hope, the opposite to that of vorticity being shed from the trailing edge; the lift is increased at a given incidence, possibly by 50 per cent.

Theory shows that for very low aspect ratio wings the lift curve slope varies with aspect ratio—R. T. Jones deduces the expression $C_L = \frac{\pi}{2} A\alpha$, which clearly can only be valid for $A < 4$; more exact studies show that it is satisfactory for $A < 2$. He also shows that in the case of the delta planform the lift curve slope is invariant with Mach number. These results have immense, though by no means straightforward, application to the "double delta" planform of the S.A.A.B. "J.35," seen on Plate 13. While the inter-relationship between two parts of the same aerofoil is clearly a subject for empirical investigation, it might be surmised that at high speeds induced drag is comparable with that of a 60 deg. delta, but in the low speed condition the separated flow and reduced incidence show a saving in drag.

This would be a particularly desirable effect, since if wave drag denies the aircraft a horizontal stabiliser, control leverages are low and trim drag is high, whatever the importance of skin friction. Designers who reject the relatively high drag of an extremely narrow wing, and resent the difficulty of supporting upon an undercarriage near the centre of gravity an aircraft that approaches at a great angle and extends far behind its c.g. at roughly the same level, prefer to allow the leading edge to become

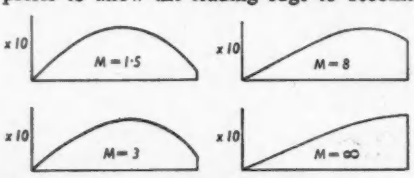


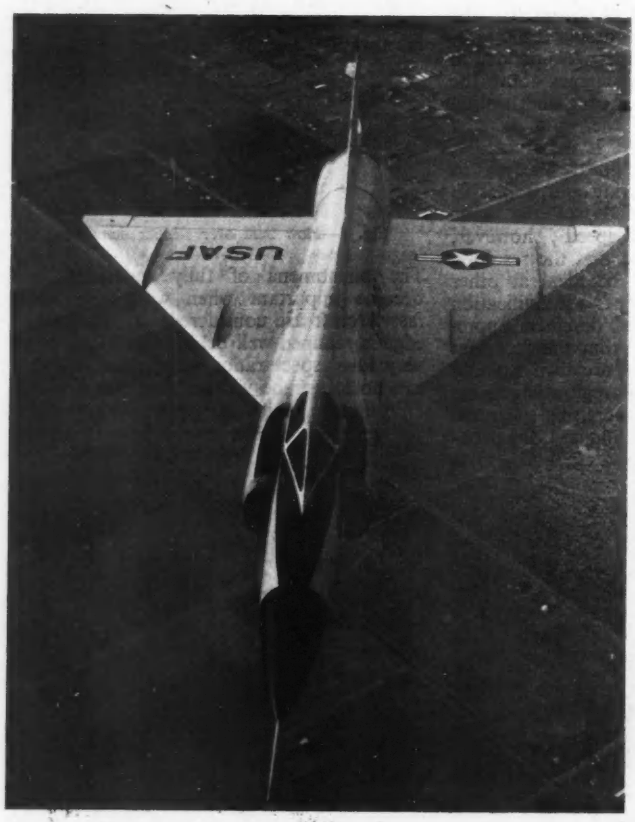
Fig. 10—Optimum sections for bending stiffness in solid construction

supersonic. It has already been mentioned that this may not involve a radical change in section, since large—comparatively—leading edge radii are not popular. Such fully supersonic deltas as we are now considering have again the problem of control surface drag, since a large trim change is involved as the Mach cone reaches the leading edge. For this reason their proponents expect them to stop short of hypersonic flight.

An interesting essay on the form of the delta is the Nord "Griffon"; in Fig. 5 there can be distinguished a fore plane above and in front of the wing. The great virtue of this is clear; assuming that the aircraft is normally trimmed for landing and take-off, the nose-down change of trim at supersonic speeds will call, not for an extravagant down load at the rear of the wing, but for the fore plane to share the lift. Equally clearly, a hitherto little trodden field of aerodynamics—tandem wings in incompressible flow—is entered, and problems may be expected; it is noteworthy that even the weapon designers, who normally locate the control gear of an active or self-propelled missile in the nose, frequently run their services to moving surfaces at the rear to avoid the complicated effects resulting from the controls altering the flow over the wings behind them.

Another French delta of not dissimilar performance is the Sud-Est "Durandal" of Fig. 4. This is aerodynamically more conventional, with the immense fin commonly seen on these short fuselages; unusual is the strake below the fuselage, which can be seen clearly on the nose wheel door.

Reverting now to aircraft with tails, we already see a number of deltas so adorned; one example is the efficient little Douglas "Sky Hawk," one of the few subsonic pure deltas, which presumably requires highly effective longitudinal control for successful carrier landings. Among supersonic deltas, tails are seen on the 60 deg. designs of Sukhoi, but the very large fuselages, twice as long as the span, may indicate large fuel loads and imply trim changes. However, the reduced lift curve slope of the delta incurs a penalty in wave drag once a separate stabiliser is selected, and thus it is not surprising that a group of aircraft which is intended for combat at high Mach numbers is appearing with wings swept little if at all. For examples



Figs. 8 and 9—Even numbers [in the "Century Series" are the Convair "F-102A" (Left) and the Lockheed "XF-104" (Right); in comparing them, it should be borne in mind that one is designed to fly twice as fast as the other. The delta shows clearly the influence of area rule, particularly in the bulges behind the trailing edge: that at the root of the fin houses air brakes. An all-weather interceptor, it carries six "Falcon" missiles. The slightly swept anhedral wing of the fighter has full-span leading edge flaps and large chord flaps and ailerons: conspicuous are the tails on the drop tanks to damp the torsional mode, and there are small fins near the leading edge to prevent breakaway. The air intakes are designed to reject a remarkably deep boundary layer. A Curtiss-Wright "Sapphire" of 10,500 lb allows Mach 1·8; production "Starfighters" (see Plate 16) use the General Electric "J-79" with reheat

of design in this category of performance it is necessary to study foreign practice.

Once a wing with supersonic edges is accepted, the section is in all probability determined largely by engineering considerations ; in particular, the minimum thickness that can be used will be a structural problem. The leading edge radius also will, under simple theory, be a minimum, but this again will be modified in practice ; at to-day's supersonic speeds a small finite radius does not carry an unacceptable drag penalty, and it does reduce both the temperature maldistribution due to kinetic heating and the liability of the edge to damage. In theory a round leading edge has another advantage; on any body, the shock wave will actually precede the wing by a finite distance, and the stagnation point will be in a zone of subsonic flow. If the edge is sharp, there will be only a narrow band of incidence in which boundary layer separation does not occur behind the leading edge. It may be added that this effect has not been found prejudicial when it has occurred. It may well be, however, that before the hypersonic régime is reached blunt entries will be confined to cones and not planes, and materials will have to be evolved to stand the temperatures involved. Consideration of the question of separation in high-speed flight leads to that of separation in the approach ; as mentioned above, symmetrical wings of such thicknesses as are proposed for supersonic flight must be expected to suffer this, and designers must console themselves with the small improvement in lift curve slope that a sharp leading edge can bring. (It is amusing to contemplate designers emulating aeromodellers and introducing " turbulators " to avoid laminar separation.) The answer here appears to be a leading edge flap ; this, however, will call for a large angle of attack, and it is logical to increase the camber still more with trailing edge flaps. Still on the subject of the leading edge, it may be observed that for a thin wing supported only at the root, the stiffness of the edges obviously becomes critical, and a certain amount of sweep may be imposed by this consideration. A search for structural efficiency, however, is likely to lead us quickly to a delta.

Turning now to the trailing edge, another marked divergence between theoretical and practical ideals emerges. It can be shown and easily credited that at increasing Mach numbers the depression, and therefore drag, on the base of a body becomes less compared with the pressures on the forward facing surfaces ; this is, of course, the justification of the ordinary artillery missile. If then a section is designed for structural stiffness or for internal tankage, the optimum wing section will show a blunt trailing edge, the distance aft of the point of maximum thickness increasing with Mach number. Fig. 10, taken from the aforementioned monograph by T. Nonweiler, illustrates this. While this design feature would clearly ease the problem of installing ailerons and control motors, it has not been seen in practice, although some hint of its approach is seen on the ailerons of the " X-2" in Plate 16. The reason for the thick trailing edge here, however, is that it avoids control reversal in the transonic range, and also prevents aileron " buzz," probably by locating the attached shocks.

The shape of the wing is more easily predicted or explained than that of the tail. The zone influenced by the wing is to be avoided — the weapon designers, it will be recalled, use what might be rendered as a " butterfly tail " to solve this problem—while large trim changes must be expected and, if flight is to extend to low indicated speeds at extreme altitudes, significant inertia coupling effects. One solution is to mount the tail plane on the fin, which offers a more attractive root junction than a round fuselage. It may be added that it is coming to be accepted that the stability and control characteristics of such aircraft will not render them suitable for human pilots to fly by judgment. Stability will be artificially derived from an inertial detector, and the pilot will initiate commands, not corrections ; this is no more than a step forward once the integrated flying control system is installed. The pilot who is observing, or even differentiating, the attitude angles of the aircraft is doing no damage to any enemy.

The most prominent example of these techniques is the Lockheed " Starfighter " of Fig. 9. This is propelled to great speeds by a General Electric " J-79 " with several stages of variable incidence compressor blades, and is expected to have a service ceiling of 70,000ft. It is not a heavy aircraft among modern fighters, grossing 17,500 lb, and it is less than 22ft in span. By published accounts, it is a machine that finds great favour with its pilots.

The " Starfighter " has been described as a " missile with a man in it," but that style is perhaps more appropriate to the French " Trident " interceptor, which in its Mark IV form is intended to dispense with a pilot. In accordance with missile practice, each of the three tail surfaces (see Fig. 11) is movable ; the disposition of these surfaces is, however, somewhat surprising, since the " Trident " must " twist and steer " like an ordinary aeroplane, and control in roll would appear to involve two different non-zero inputs to the control surfaces if yaw is not to be imposed as well. It may be surmised that the lower planes cannot be brought closer together without infringing the ground clearance ; already there appear to be small bumpers on the tips. The wing, interestingly enough, is untapered—some reinforcement for the tip will come from the engine nacelle—and the piloted version has a full span of trailing edge flap. Mach 1·6 is exceeded, but the outstanding claims, as would be expected of a rocket interceptor, are for rate of climb and ceiling. Although it might be thought that such a machine would be designed for minimum drag at some speed less than its maximum and possibly near Mach 1, there is no sign of the " coke bottle " about the fuselage. Of course, if maximum speed was sought, the cross section of the engine nacelles would influence the fuselage near the long and slender nose.

(To be continued)

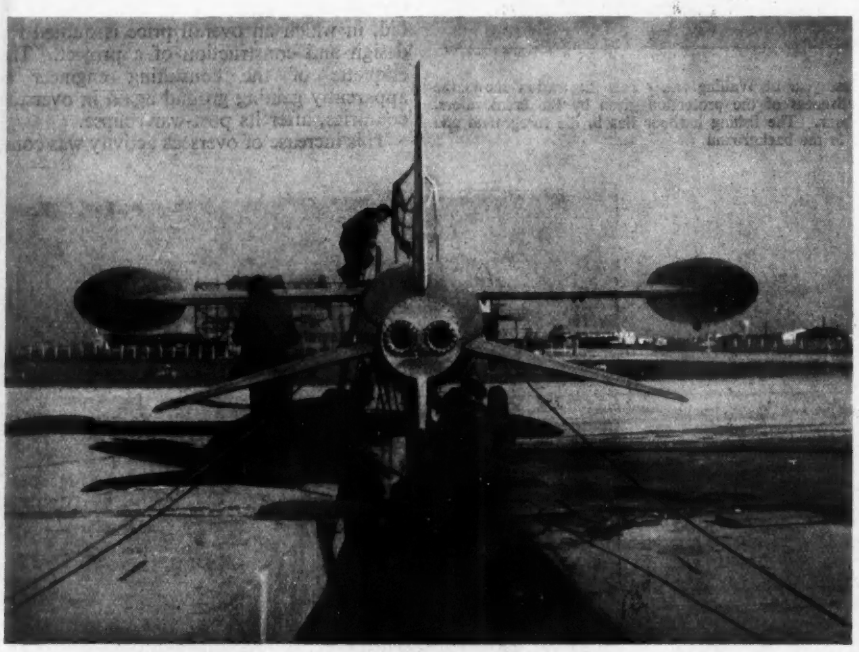


Fig. 11—A tail view shows the three engines of the " Trident II "—two turbo-jets and a double-barrelled 11,000 lb rocket. Taking-off at about 113,500 lb weight, the fall in weight and improvement in rocket thrust counter the loss of jet power and give a constant rate of climb to any height safe for the pilot, who presumably has no pressure suit, passing 50,000ft after two-and-a-half minutes

Technical Reports

The Subsonic Flow Past Swept Wings at Zero Lift Without and With Body. D. Küchemann, Dr. res. nat., and J. Weber, Dr. res. nat. R. and M. 2908. H.M. Stationery Office. Price 17s. 6d.—The inviscid flow past swept wings at zero lift is reviewed and methods of obtaining the full benefit of sweep described. Detailed solutions of incompressible flow are given for three cases : a wing of infinite span ; the centre section of a wing of infinite span, and the flow in a curved intersection between wing and body. These solutions are used to find approximate solutions for any wing of finite span. The Prandtl-Glauert procedure is extended and applied to derive approximations for the compressible flow in the sub-critical region. Special cases treated in detail are : flow near the tips of wings ; tapered wings ; wing-fuselage interference for symmetrical arrangements, and modifications to the shape, for instance, to restore sheared-wing conditions.

A Constructional Method for Minimising the Hazard of Catastrophic Failure in a Pressure Cabin : Current Paper No. 286. By D. Williams, D.Sc., M.I.Mech.E., F.R.Ae.S. H.M. Stationery Office. Price 2s.—A method is put forward for substantially reducing the chances of a local failure in the shell of a pressure cabin developing into catastrophic failure. The increased safety is achieved without weight penalty, and consists essentially in using closely-spaced (10in or thereabouts) transverse flat bands, the material for which is obtained by reducing the sheet thickness normally available for the shell walls.

Flow Direction Measurements in Supersonic Wind Tunnels. By D. J. Raney, B.Sc. (Eng.), A.C.G.I., D.I.C. Current Paper No. 262. H.M. Stationery Office. Price 3s.—Some general requirements for satisfactory flow direction measurements in supersonic tunnels are stated and examples are given of the design and calibrations of typical yawmeters. The results of flow direction measurements made in two tunnels are given and some of the flow characteristics are discussed.

Civil Engineering in 1956

No. 1

A YEAR of increased output, with continued technical progress, but without major events of a spectacular nature—thus 1956 may be summed up for British civil engineers and the industry which they direct. Outstanding projects completed during the year included two large overseas schemes—the Wadi Tharthar scheme in Iraq and the development works at Colombo port in Ceylon. The Volta Bridge (Plate 2) was also completed. At home, the Daer water supply was inaugurated by the Queen, and the North of Scotland Hydro Electric Board's Garry scheme was completed, and Finlarig power station was opened. An important contribution to the engineering event of the year, the opening of Calder Hall, was, of course, made by civil engineers. Nearly all of this was adequately described in THE ENGINEER at the time, and is not referred to again in this article, but brief notes are given on a number of other important works which were in progress during the year.

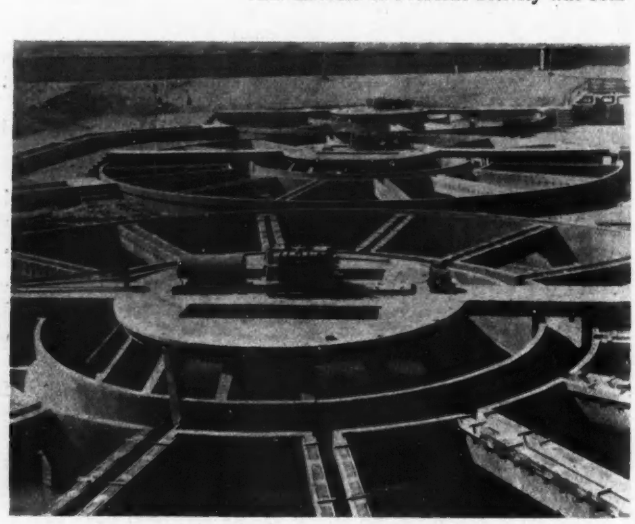
Less spectacular works, which may attract little attention, have, however, an equally important contribution to make. This can be illustrated by those two basic services—water supply and sewerage and sewage disposal. On two occasions during the year Mr. Enoch Powell, Parliamentary Secretary to the Ministry of Housing and Local Government, spoke about the progress of such works when he opened two rural water supply schemes. He pointed out that the number of households without a piped water supply had been halved in the last five years; by the end of the year the mileage of water mains in the country would be half as great again as when the war ended, he said. Rural water schemes were being approved at a rate of £6,500,000 annually. He also pointed out that the rate of investment in water supply had to be matched by expenditure on sewerage; in the last financial year £22,000,000 had been authorised to be expended in England and Wales on water schemes (exclusive of most of the work done by water companies as opposed to other undertakers) and £30,000,000 for sewerage.

The Ministry of Works' statistical data for building and civil engineering (provisional figures for the third quarter of 1956 were available at the time of writing) showed a continuation of the annual increase in output which has been maintained since the war, an increase of 16, 25 and 25 per cent respectively for the first three quarterly periods, over the 1948 datum figure, based on the volume of work done (i.e. allowing for a cost index of 136 over 1948). Housing does not seem to have increased *pro rata* over last year's figures, thus indicating greater activity in industrial new works. There are no statistical data available for civil engineering alone, so these figures give only a rough guide, which can be supplemented, as we have indicated in previous reviews, by reference to our *Tabular Summary of Civil Engineering Contracts*, the 1956 edition of which was published with our issue of December 21 last. The *Tabular Summary* lists contracts actually in progress, most of which take several years to complete, and the small jobs, below £50,000 in value, are not included. It shows an increase in the total amount of work in progress, but the proportions of work in the various categories remain similar. One noticeable change, however, is shown in the total value of works in progress abroad, for which British consultants are responsible. Two years ago the total value of the overseas contracts listed stood at just over £200 million, and this figure has now increased to over £300 million. A possible reason may be the diminishing popularity of the "turnkey" bid, in which an overall price is quoted for design and construction of a project. The etiquette of the consulting engineer is apparently gaining ground again in overseas countries, after its post-war eclipse.

This increase of overseas activity was com-

Tests on a model of Tema Harbour were completed last year at Wallingford. This illustration shows the model while under test, and clearly indicates the effectiveness of the protection given by the breakwaters. A radio controlled model ship is entering the main harbour. The fishing harbour lies in the foreground and the wave generator is in the background

Construction of the main breakwater at Tema harbour. Tipping of rock in the construction of the approach arm to No. 2 quay is in progress, a stage reached by July of 1956



Three of the six 23·5m diameter "Accelators" provided for treating the water to supply the million population of Iran's capital city, Tehran, with an average of 250 litres per head per day

mented upon during the year in the *Board of Trade Journal* at the time of an exhibition of photographs of overseas works. It was pointed out that the value of work done by British contractors overseas totalled £87,000,000 in the year ended March 31, 1956, as compared with £70,000,000 in the previous year. Fifty-five contracting firms were involved and the work was in sixty-two different countries. Contracts obtained during the same yearly period totalled almost £109 million, and work outstanding at the end of the period was £115 million—both considerable increases over the year before. Welcome increases were shown in the work in dollar areas, but it still remained only a small fraction of the total.

These figures do not, of course, refer to exactly the same jobs as do our own totals from the *Tabular Summary*. In some cases British consultants are directing the work of foreign contractors, and vice versa. The most notable example—one which received its due share of publicity at the time—was that of the Kariba dam, where contracts to the value of £35,000,000 were let during the year, principally to an Italian consortium. The scheme was described in our issue of August 3 last. Another project of even greater size, for which British consultants—Sir Alexander Gibb and Partners—had been appointed, also caused disappointment during the year, and is held by some to be one of the principal causes of the events in the Middle East. We refer to the Aswan high dam scheme; financial support from American and British sources was withdrawn during the year, and subsequent events are too well known to need further notice here.

The report of the preparatory commission appointed to investigate the Volta River project in the Gold Coast was also published during the year. The project was declared technically sound and economically feasible. It involves, ultimately, the production of 210,000 tons of aluminium annually from the following new works:—Bauxite mines around Aya and Yenahin; a dam and power station at Ajena, generating 600MW and creating a lake 3500 square miles in area; an aluminium smelter and township at Kpong; new railways, and the completion of Tema port. However, a note of caution was sounded officially at the time the report was published, and as yet none of the promoters are definitely committed. It was pointed out that the next stage would involve an agreement between the United Kingdom and Gold Coast Governments and the aluminium companies involved, and reviewing the financial arrangements. The total cost was estimated at about £230 million for the complete scheme, and £185 million for the first stage, in which 120,000 tons of aluminium would be produced annually.

In the meantime, work continued during the year in the Gold Coast on schemes associated with the Volta River project, but which are, nevertheless, to some extent separate developments. The principal work is, of course, the port of Tema; accompanying illustrations show the model of the port at the Hydraulic Research Station at Wallingford, where investigations of the harbour were completed during the year, and also construction of the main breakwater in progress.

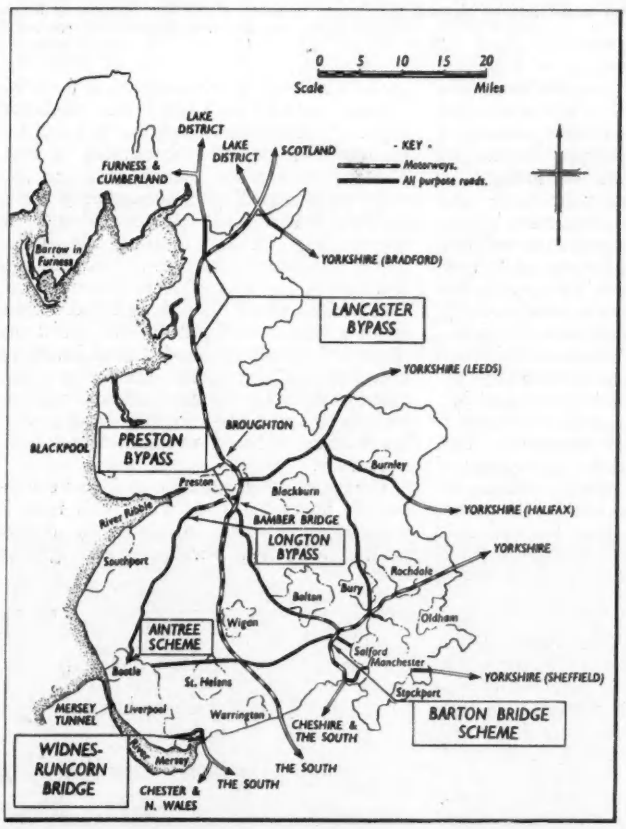
Four deep-water berths are to be constructed initially, together with the appropriate transit and storage facilities, railway marshalling yards, and buildings. The site has already been linked by rail to the existing main line just north of Accra and new roads have been built to connect with the existing road system and with the trunk roads which are in course of construction between Accra and the new Volta Bridge. In the lee of the main breakwater a fishing harbour is to be built, in which it is intended to establish a fishing fleet with locally built trawlers.

The rock-filled main breakwater reached a point some 1800ft from the shore line by the end of 1956, and the rubble hearting for the four-berth quay was advanced from the side of the breakwater for a distance of about 800ft. Preparation of the seabed was under way preparatory to the construction of the quay walls. Plant on the breakwaters included two PH.1500 and one Lima 2400 cranes as well as bottom opening and side tipping barges.

For the winning of the breakwater rock, two quarries have been opened in the Shai Hills. The first, at Tetedwa, had produced some 350,000 cubic yards of rock in sizes up to 10 tons by the end of the year. The second, at Mampong, was not in full production. Quarrying was largely on benching systems using "Quarrymaster" and "Drillmaster" equipment. Heading blasts were also carried out, one at Tetedwa, producing some 18,000 cubic yards. Plant at the quarries included two 4½-yard and three 2-yard shovels, electric and diesel.

Excavation and reclamation in the shoreward areas was under way, largely with shovels and nearly half of the required 2,000,000 cubic yards of material had been moved. An extensive and fully equipped blockyard had been built for casting the 16-ton concrete quay wall blocks, of which some 1200 were made by the close of the year. The harbour power station containing three 650kW diesel sets was virtually completed. The building has a steel frame clad with concrete blocks and asbestos cement sheeting, and has provision for two additional 1100kW sets. The installation has the usual auxiliaries, bulk fuel storage tank, rail siding and sewerage system, and timber cooling towers. Distribution is by underground cable at 11kV to substations.

The contractors are Parkinson Howard, Ltd., and the consulting engineers to the Gold Coast Government and Gold Coast Railway are Sir William Halcrow and Partners, with Messrs. Ewbank and Partners as electrical and mechanical consultants for the power station. Extensive hydraulic model experiments have been carried out by the Hydraulic Research Station, Wallingford, to determine the best design for the breakwaters and to confirm the suitability of the general layout of the harbour. This work has provided valuable information which has been incorporated in the designs and is now virtually complete (see THE ENGINEER, November 9 last).

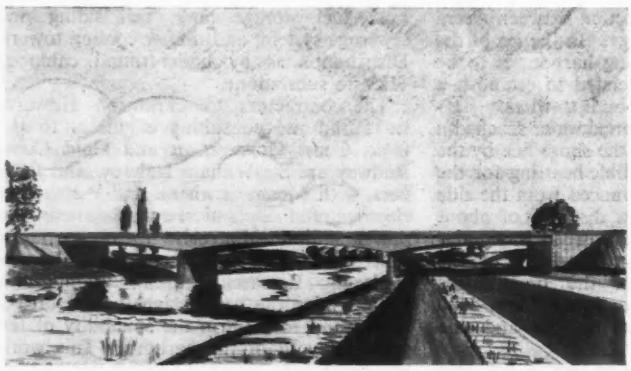


The Preston by-pass, construction of which started last year, will be the country's first motor road. Its relationship to other motor roads planned in Lancashire is shown, as are several other improvement schemes in the county

By the end of 1956 the latest of a series of sections of trunk road leading from Tema towards the Volta Bridge (Plate 2) into Togoland was substantially completed. It included 12 miles of fast motor road, which consisted of a 22ft tarmac carriageway with laterite verges on either side. In addition, the earthworks for 5 miles of dual carriageway were completed. The road was designed for heavy duty on the CBR method and the base was mostly of crushed stone, while the subbase was normally of laterite. A number of bridges, culverts and roundabouts were included. In the middle of the year, the Kpeshi Lagoon Bridge carrying the main road eastward from Accra towards Tema and the Lower Volta area was reconstructed. The tops of the existing abutments and the central pier were somewhat modified, but the main part of the reconstruction was a new deck consisting mainly of precast, prestressed concrete beams made in England and erected on site with concrete filling. The work was done in two halves so that heavy lorry traffic could be maintained over the bridge at all times. Loading tests were made on the prestressed beams before they left this country, and some observations of curvature were continued on site, from which it was clear, we are informed, that a loss of prestress of 20 per cent should prudently be expected in this type of standard beam. The site work required was very suitable for relatively unskilled labour.

The consulting engineers for these roadworks were Sir William Halcrow and Partners, and the contractors Stirling Astaldi (West Africa), Ltd., and Brun, Ltd.

Some mention might also be made of other large overseas schemes. The Wadi Tharthar scheme in Iraq was inaugurated early in the year by King Feisal. In the same country the Dokan irrigation scheme was also in progress; the 385ft high arch dam of this scheme is scheduled for completion in 1958. The



Artists' impressions of the two major bridges carrying the Preston by-pass. (Left) The Salmesbury bridge over the River Ribble and road A59. (Right) Higher Walton bridge over the River Darwen and road A675

total cost of each of these two schemes is of the order of £10,000,000. Others of equal magnitude in progress in 1956 included a scheme for a piped water supply for the city of Tehran in Persia. The consultants for this work are Sir Alexander Gibb and Partners, and British plant and materials are being supplied, but the contractors are local firms. We illustrate a battery of "Accelators" installed as part of the purification plant of this scheme. In the same country, construction was proceeding on the Abadan-Tehran pipeline of the National Iranian Oil Company, for which the consultants are Messrs. Rendel Palmer and Tritton and Mr. A. C. Hartley, and the contractors Costain-John Brown and Société Entrepôts. Two hydro-electric schemes of the same order of magnitude, with which British consultants were concerned, were also in progress during the year—the Aswan dam hydro-electric scheme in Egypt and the Rio-Caroni-Macagua scheme in Venezuela.

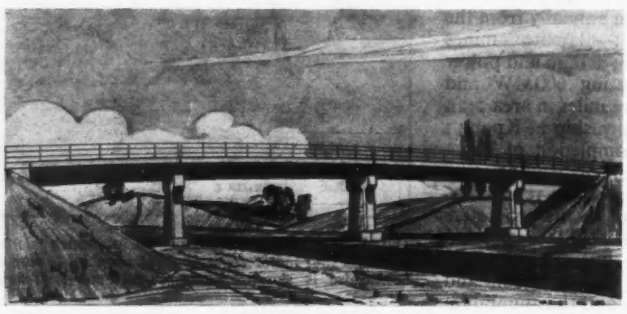
Britain's First Motorway

The plight of Britain's road system becomes worse each year, as motor traffic increases. The Government's road programme cannot be said to have been well under way in 1956, but at least one important practical step was taken. Last June work was inaugurated on the Preston by-pass, an 8¼-mile length of highway built to motor road standards, which will eventually form part of Lancashire's North-South motorway. The scheme now in progress is between Bamber Bridge and Broughton, as indicated on the accompanying sketch, which shows the main routes in Lancashire's road plan. It is under the direction of the county surveyor and bridgemaster, Mr. James Drake, and the main contract, valued at nearly £2,500,000, for the motorway is let to Tarmac, Ltd.; this contract includes twenty-one bridges, which are subcontracted to Leonard Fairclough, Ltd. Two larger bridges form separate contracts, namely, Salmesbury Bridge, which is to be built by the Cleveland Bridge and Engineering Company, Ltd., and Higher Walton Bridge, which is to be built by Dorman Long (Bridge and Engineering), Ltd.

In general, the overall width of the by-pass is 112ft, with dual carriageways 24ft wide. A contrasting marginal strip 1ft wide flanks each carriageway, providing an effective width of 26ft. The outer verges are 14ft wide, including an 8ft width constructed to form a hard shoulder abutting on to the carriageway. A central reservation, 32ft wide, is provided to allow for an ultimate widening of carriageways from two lanes to three and still leave a reservation 12ft wide.

Earthworks amounting to 2,250,000 cubic yards of excavation are necessary to form the cuttings and embankments. The maximum depth of cutting encountered is 62ft and the maximum height of embankment is 56ft. The preliminary soil survey gave the soil types encountered as predominantly clays, with wet sand and silt veins occurring at the deep cuttings; a more detailed soils investigation was made at the sites of these cuttings and also at the sites of high embankments. This work involved the sinking of bore-holes up to a maximum depth of 80ft, whilst the whole soil survey involved a total length of over 5000ft of bore-holes. The design of the slopes of cuttings and embankments, together with special provisions for face drainage and stabilisation, is based on the findings of the soil survey.

The weak clay subsoils and the exceptionally heavy loads for which this road is designed necessitate in places a deeper construction than normal. The greater part of this consists of a local waste product, burnt colliery shale, which will vary in depth from 4in to 19in. The shale sub-base is covered with a 9in thickness of premixed waterbound macadam and the road initially surfaced with ¾in asphalt on a 2½in tarmacadam base course. Later, after settlement has taken place, a rolled asphalt wearing coat will be laid. Kerbs will not be provided except at bridges, and rainwater will run away to the side verges and central reservation, where it will be collected into precast concrete channels or french drains. This form of surface water drainage enables the road to be constructed to flatter gradients.



Artist's impression of a typical road bridge crossing over the Preston by-pass. The main beams are of prestressed precast concrete

Salmesbury Bridge carries the motorway over the River Ribble and Trunk Road A 59 at a point east of Preston. The bridge is designed as a three-span, curved soffit, continuous steel girder of spans 120ft, 180ft and 120ft giving a total overall length of 420ft between abutments and a width of 94ft between parapets. The steel girders will be supported on masonry faced piers and abutments. Higher Walton Bridge carries the motorway over the River Darwen and the Class 1 Road A675 in Walton-le-Dale, and is a multi-span continuous steel girder bridge with four main spans of 97ft 6in each, and two end spans of 42ft, giving an overall length of 474ft. The width of the bridge is 94ft between parapets. The bridge carrying the railway over the motorway at Ribbleton is being designed by the British Transport Commission, the deck being of steel girder construction with a square span of 99ft. These three bridges are being constructed under separate contracts, whilst the remaining bridges form part of the main contract for the by-pass. For the bridges in the main contract it is worthy of note that more than half—in fact, twelve—will have prestressed concrete decks, this being the first time that prestressed concrete has been used to this extent in any major road scheme in this country. Two other bridges will be constructed in steelwork and the four foot-bridges and three culverts in reinforced concrete.

The design of the road is noteworthy not only for the adoption of full motor road standards — dual carriageways, grade separations, hard shoulders, and so forth, about which so much has been heard and so little seen—but also because of the major use of premixed mechanically laid waterbound macadam, and because of a specification which allows a high degree of mechanisation such that the scheme will be completed in two years.

Lancashire's road development programme —of which this road and the future motor roads and main routes shown in the sketch on page 21 form a part—is based on a thirty-year plan formulated nearly eight years ago. Mr. Drake reviewed the progress of this plan recently in a paper read last November at the Public Works and Municipal Services Congress. Apart from the Preston by-pass, he noted, contract drawings were being prepared for the second length of the north-south motorway—the 12-mile Lancaster by-pass—work on which is scheduled to start this year. Authorisation had been received, he continued, for the 6-mile westerly by-pass of Stretford and Eccles, including the high-level bridge at Barton, on the

Manchester Ship Canal, and preparations were well under way for a further length of the north-south motorway from Preston to Cheshire. Construction had commenced on three other schemes, viz. dual carriageways on the Liverpool–Preston trunk road A59 at Aintree, 1 mile in length; 2½ miles of dual carriageway by-passing Longton on the same route; and the new Widnes–Runcorn high-level bridge over the Manchester Ship Canal and the River Mersey, which was a joint scheme with the Cheshire County Council. If work proceeded in the future at the same rate as in the past seven years, Mr. Drake pointed out, the thirty-year plan would take twenty times that period to complete; but the construction authorised for the next three years had altered the picture considerably, and if the present rate could be maintained, the future could be faced with some optimism.

As regards the country as a whole, estimates for Government expenditure on trunk roads in 1956–57 were put at just over £7,500,000 for new construction, and just over £11,500,000 for maintenance and minor improvements. Corresponding figures of grants to highway authorities for classified roads were nearly £8,500,000 and £23,500,000 respectively in the two categories. The figures for new construction may be compared with the figures for expenditure on water and sewerage schemes, quoted earlier. Authorisation for new schemes were £6,000,000, £19,000,000 and £28,000,000 in 1953–54, 1954–55 and 1955–56 respectively, and are expected to be £34,000,000 in 1956–57. The actual expenditure is generally spread over several years subsequent to authorisation. If the plans announced in 1955 are realised expenditure will rise from £8,500,000 in 1955–56 to £42,000,000 in 1958–59.

(*To be continued*)

Shipbuilding and Marine Engineering in 1956

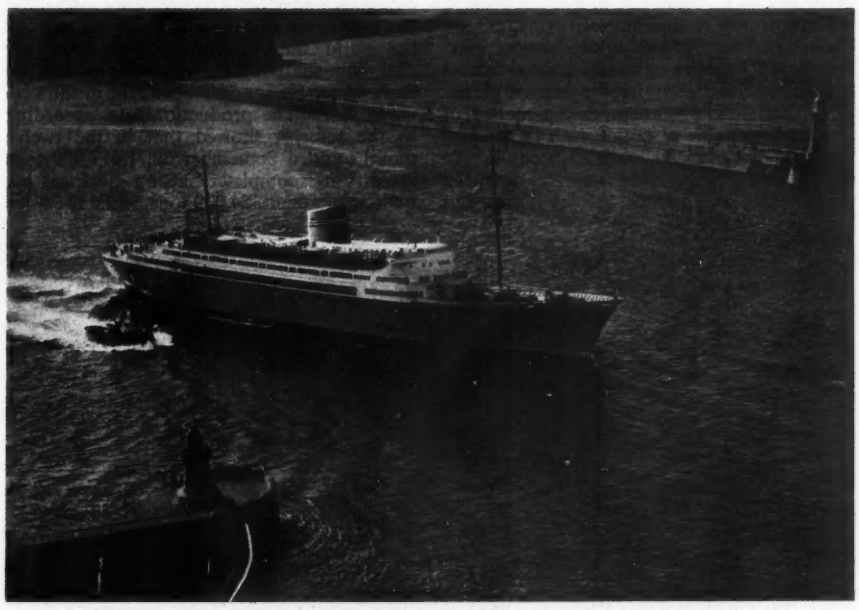
No. I

THE end of 1956 marked the completion of two decades of continuous activity in shipbuilding, for it was in 1936 that the industry really started to recover from the doldrums of the early 1930s and the slump conditions of 1932 and 1933. The return to the ordering of ships so apparent in 1955, when contracts for 386 ships of 2,328,000 gross tons were placed, was continued during 1956, although the tempo was slightly reduced. However, in the first quarter of the year, the shipyards received orders for seventy-three ships of 316,000 gross tons, and this was followed in the next quarter by orders for sixty-nine ships of 436,000 tons, while in the third quarter contracts for a further eighty ships, representing 514,000 gross tons, were placed, bringing the total for the first nine months to 222 ships of 1,266,000 gross tons. During the final quarter of the year orders continued to be allocated and, although returns for the period are not yet available, it was estimated that the total for the twelve months was not far short of 2,000,000 gross tons. After making due allowance for ships completed it was estimated that the order book total, which stood at 5,287,000 gross tons at the end of 1955, approached 6,000,000 gross tons at the end of the year. This represented approximately 850 ships approaching in value £790 million.

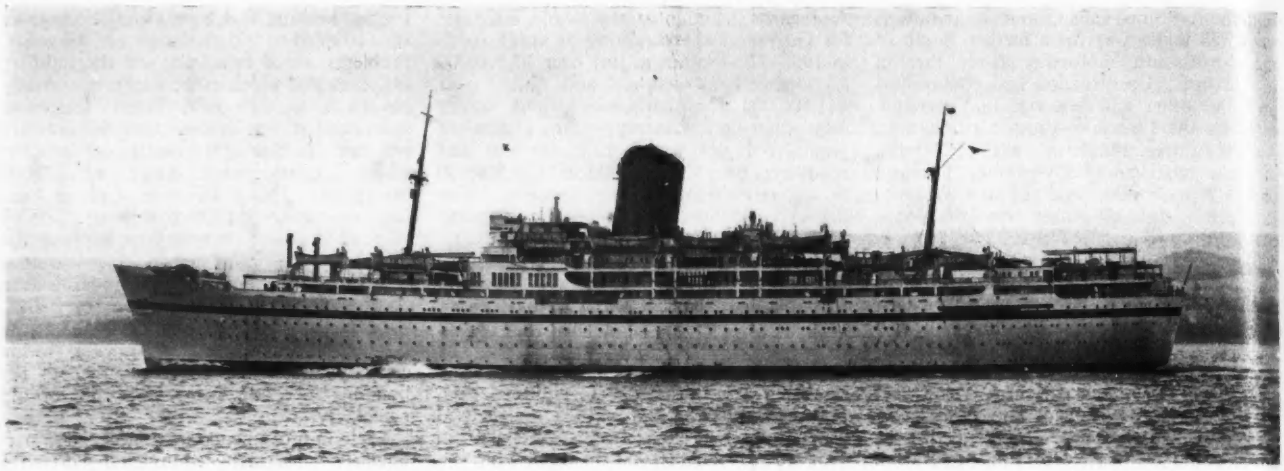
Orders for foreign account amounted to about 21 per cent of the total, which was fairly representative of all varieties of tonnage, although oil tankers continued to dominate. This class of tonnage accounted for 51 per cent of the total, while cargo ships represented 33 per cent, ore carriers 7 per cent, and passenger and passenger/cargo ships 6 per cent, the remaining 3 per cent representing smaller craft and special ships. With such a large backlog of orders the industry must be regarded as being prosperous, at least in the statistical sense. However, when it is recalled that only 1,322,000 gross tons of ships were completed in 1955 and that the estimated output for 1956 is 1,400,000 gross tons, it is evident that intake of orders greatly exceeded output. At the current rate of output the orders in hand represented about four years of work, but with oil tanker and ore carrier tonnage accounting for nearly 60 per cent it is evident that many non-tanker building yards had much smaller order books. Nevertheless, the general picture at the end of the year indicated continuity of work and security for some time into the future.

A number of factors contributed to the smallness of the output returns, noted above, including official and unofficial strikes widely differing in character, but all resulting in complete, partial or local stoppages and causing schedules to be upset, and dislocation of production plans with a consequent postponement of delivery dates. However, the biggest limiting factor was the shortage of steel coupled with out-of-sequence deliveries, problems which have plagued the industry for years, and which in the final event directly govern the tonnage built. Due to the causes mentioned it was evident that the industry was not functioning at maximum capacity, which is considered to be about 1,750,000 tons gross. This is a matter of regret since large capital investments have been made by shipbuilders over the years to improve the efficiency of the yards and so increase output with the same labour force. Modernisation plans included the improvement of berths, the expansion of prefabrication facilities, the installation of cranes of greater lifting capacity and giving better coverage of the building slips and the replacement of old machinery.

Such improvements were necessary, particularly when many continental yards had been rebuilt, and so were able to make a fresh start unhampered by old equipment, out-of-date buildings, congestion and poor internal transport. Modernisation schemes completed, in being and projected put British on a par with foreign yards. It is lamentable that the constructional facilities available are not being economically used, a state which directly contributes to the high cost of ships. New yards have been suggested as the solution of the production problem, but this would only divert steel supplies and so make the situation worse. In addition, there would be the problem of personnel, a problem difficult of solution since the present labour force is already fully employed. This steel shortage had another effect—that of creating a sense of frustration in those engaged in the industry, since extra effort did not result in an overall increase in production. It was evident that higher production in the steel mills had not benefited the shipbuilding industry to any significant extent, and that any steel made available as the result of credit restriction had not found its



The Norwegian America Liner "Bergensfjord," which is shown leaving the River Tyne, was built at the Wallsend yard of Swan, Hunter and Wigham Richardson, Ltd., and launched by Her Royal Highness Princess Astrid of Norway. A total of 101 first-class and 746 tourist-class passengers are carried, and the ship, which has an extensive aluminium alloy superstructure, has a length overall of 587ft, a breadth moulded of 72ft, a depth moulded to "B" deck of 38ft 6in, a load draught of 27ft 6in, giving a displacement of 17,500 tons, and a gross tonnage of 18,738. A service speed of 20 knots is maintained by two Stork, double-acting, two-stroke, diesel engines, having eight cylinders of 720mm bore by 1100mm stroke, developing a total of 18,400 b.h.p. at 128 r.p.m. Four 1040kW diesel-driven alternators provide the necessary electrical power



The troopship "Nevasa" was built and engined by Barclay, Curle and Co., Ltd., for the British India Steam Navigation Company, Ltd., and has accommodation for 220 first-class, 100 second-class, and 180 third-class passengers, and also 1000 troops. The following are the main particulars: length between perpendiculars 560ft, breadth moulded 78ft, depth moulded to "A" deck 57ft, and gross tonnage 20,527. Electrical power for the ship's services and auxiliary machinery is supplied by three 1200kW geared turbo-generators and a 450kW diesel-driven generator. The power to give a service speed of 17 knots is developed by two sets of triple expansion geared turbines, developing 13,000 service s.h.p. at 111 propeller r.p.m., and taking steam at 500 lb per square inch gauge, and 800 deg. Fah., from four Babcock and Wilcox boilers

way to the shipyards during last year.

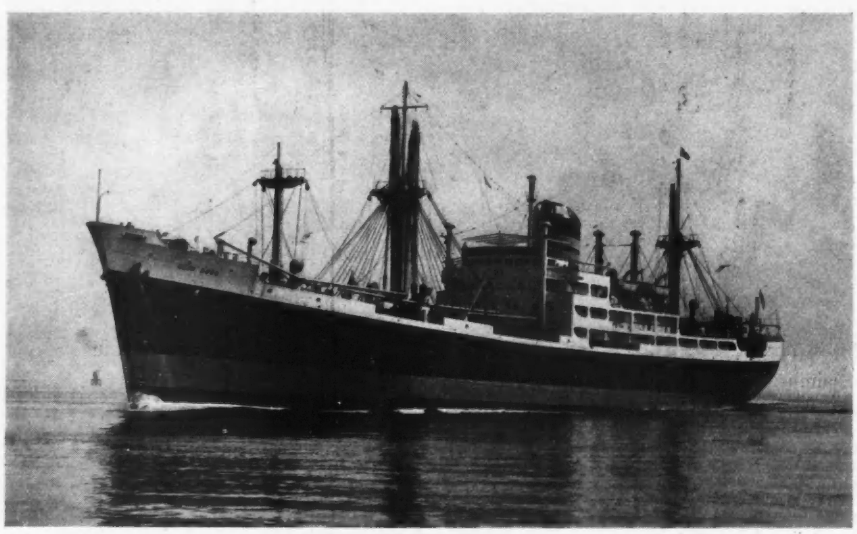
Since coal is unable to meet the growing demand for power, the increased demands for fuel have to be met, until nuclear energy can make an effective contribution, by increased oil shipments. This was reflected in the ordering of oil tankers and influenced the size of ship ordered, the average size having risen from 18,000 tons deadweight in 1946 to 45,000 tons to-day. Recently tankers of 60,000 tons were ordered in Britain, while one ship of over 80,000 tons is already afloat and vessels of 100,000 tons deadweight projected. This steep rise in size has created the problem of availability of berths, despite the fact that none of the big slips are occupied by large warships, plus questions related to the machinery to handle bigger plates. A further difficulty arises in the matter of dry docks capable of taking such large ships when in for repairs and inspection. In recent years, private industry has financed the building of a number of dry docks, but the call for still larger units underlines the need of the ship repairers for some form of support from Government sources.

Reference to the shipbuilding returns issued by Lloyd's Register of Shipping shows that at the end of September the total tonnage of steamships and motorships under construction was 2,078,000 tons gross, or about 69,000 tons less than on the same date in 1955. The total can be compared with that for the world, which at 7,449,000 tons gross had increased by about 1,164,000 tons gross during the year. These figures show that the ships under construction only amounted to 27·9 per cent of those building throughout the world and confirmed Britain's steadily declining share which was 34 per cent in September, 1955, and 37 per cent in the previous year. The production rate, according to the returns, showed that in the twelve months ended September 30, 1,417,000 tons gross were completed at an average per quarter of about 354,000 tons, while the ships completed during the first nine months of the year totalled 1,079,000 tons gross. On the assumption that the average production rate was maintained during the fourth quarter of 1956 then the total for the year may have attained 1,433,000 tons. An improvement on 1955, but nevertheless, disappointing. The tonnage commenced declined by 86,000 tons to 1,321,000 tons gross, while the total launched, at 1,350,000 tons, was 5000 tons less than for the previous twelve months. In other countries, however, increases were registered, and ships commenced increased by 1,395,000 tons to 5,618,000 tons gross, and those launched increased by 1,135,000 tons to a total of 4,796,000 tons gross.

The fall in this country's percentage of world construction has already been mentioned. German shipbuilding, however, continued to expand with world trends and maintained the same percentage of the total, while in Japan, the total of ships under construction rapidly increased to make that country, at 16·0 per cent, our strongest competitor, followed by Germany, Italy The Netherlands and France in that order.

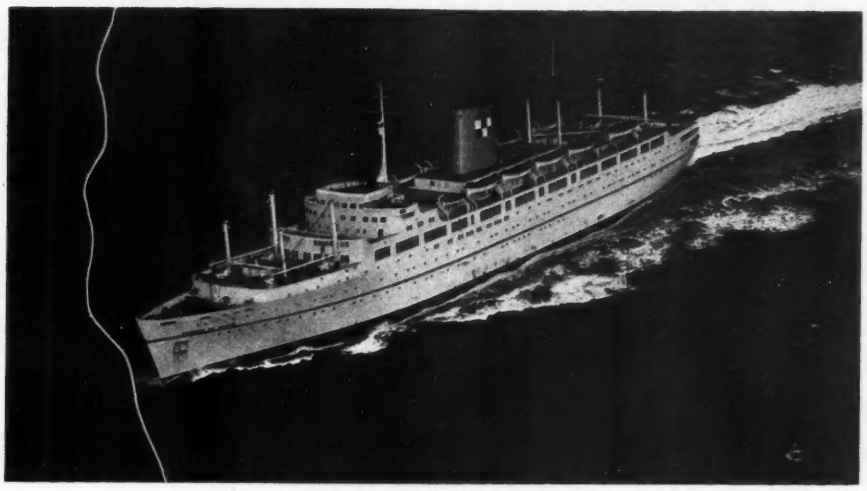
More disquieting for our position as the leading shipbuilding country was the fact that for each of the first three quarters of last year Japan exceeded the totals commenced and launched in this country by a considerable margin. This margin in favour of Japan, up to September 30, amounted to about 469,000 tons gross of ships commenced and 291,000 tons gross of ships launched. Furthermore, Japan completed about 417,000 tons gross of ships in the third quarter of the year, compared with Great Britain's total of 245,000 tons, although this latter figure was low due to the high total of completions in the previous quarter. Nevertheless, Japan in the first nine months of the year completed a total of about 1,043,000 tons gross, which was only 36,000 tons less than the corresponding British total.

In the matter of export orders, about 23·4 per cent of ships being built in Great Britain was for foreign account, a figure which reflects the reduction in orders from abroad and compares with 49·2 per cent for the remainder of the world. In terms of tonnage Japan, Germany and Sweden were building 877,000 tons, 569,000 tons and 297,000 tons gross, representing 73·6, 69·2 and 74·5 per cent of the tonnage under construction in those countries. These

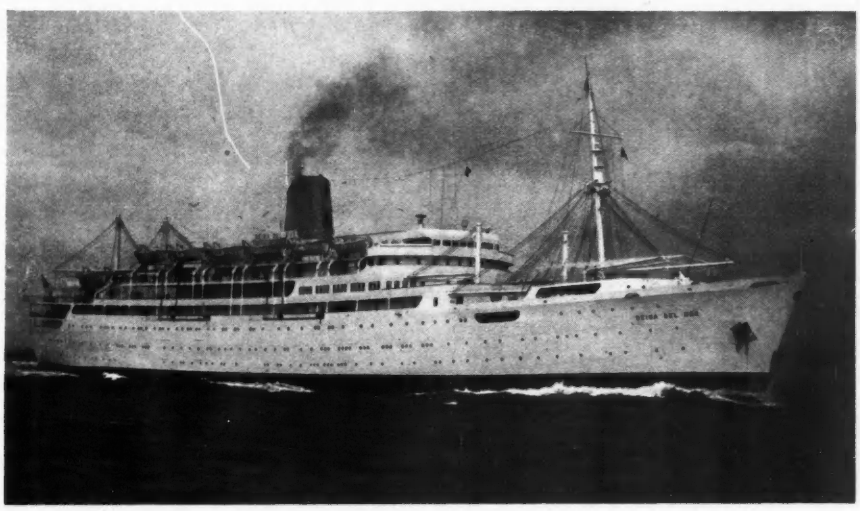


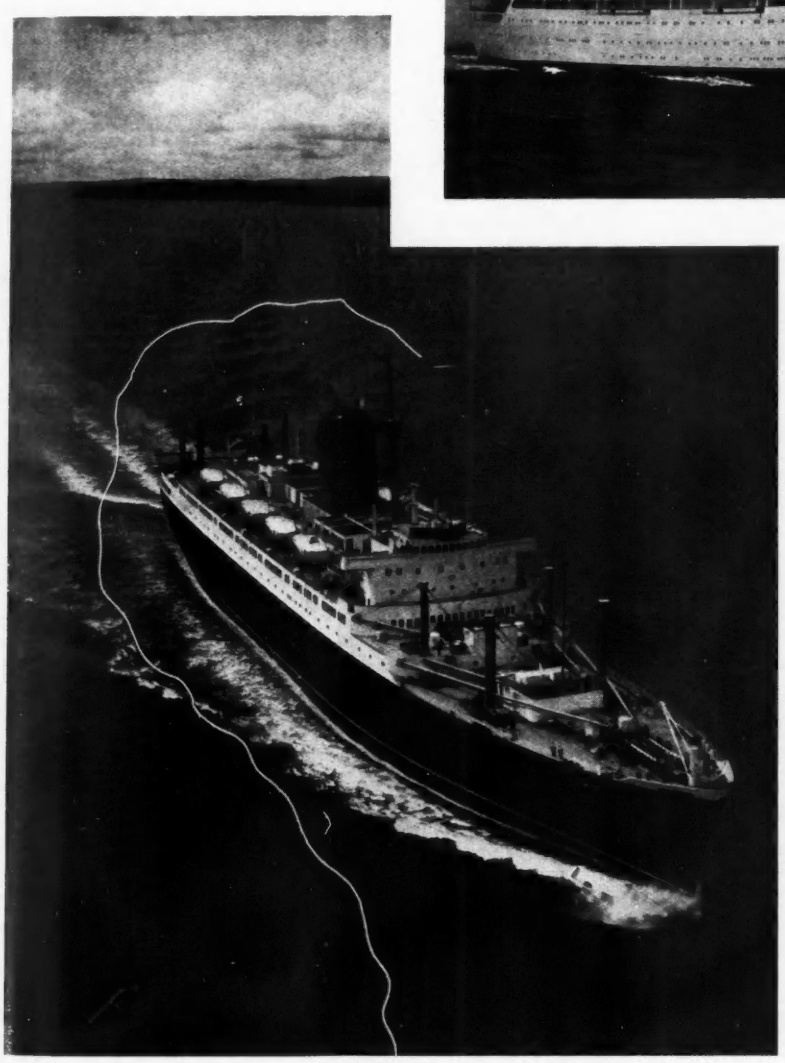
The Greenock Dockyard Company, Ltd., completed the cargo-passenger liner "Clan Ross" for Clan Line Steamers, Ltd., and the ship, which carries a deadweight of 10,075 tons on 27ft 3in mean draught, has a length between perpendiculars of 465ft by 65ft 6in breadth moulded by 39ft 7¼in depth moulded to upper deck, and a gross tonnage of 8000. There is accommodation for twelve passengers and the five cargo holds are served by one 80-ton, two 40-ton, two 15-ton, four 7-ton and ten 5-ton derricks operated by electric winches. The service speed is 17 knots and propulsion is by one set of Parsons triple expansion double reduction geared turbines of 9400 service s.h.p. at 106 propeller r.p.m., taking steam at 415 lb per square inch gauge and 750 deg. Fah. from two Babcock and Wilcox boilers operating under forced draught

Ocean Liners



The Canadian Pacific liner "Empress of Britain," upper right, sailed on her maiden voyage from Liverpool on April 20. Of 26,000 gross tons the ship, which was built and engined by the Fairfield Shipbuilding and Engineering Company, Ltd., has an overall length of 640ft by 85ft beam by 48ft depth moulded to "B" deck, and a load draught of 29ft. The service speed is 20 knots and a total of 150 first-class and 900 tourist passengers are carried, together with a crew of 464, in air-conditioned accommodation requiring refrigeration plant having a capacity of 9,000,000 B.Th.U. per hour. There are seven decks, three being continuous, and six cargo holds of 380,650 cubic feet capacity. Denny-Brown stabilisers are fitted. For propelling the ship there are two sets of triple-expansion, double-reduction geared turbines, which take steam at 600 lb per square inch and 850 deg. Fah., and develop for normal service a total of 27,000 s.h.p. at 123 propeller revolutions per minute. Steam is raised in two Foster Wheeler controlled superheat boilers of two-furnace design, and one reheat boiler which forms part of the reheat system developed by the builders to achieve fuel economy, and which raises the temperature of the exhaust steam from the h.p. turbines to 850 deg. Fah. There is also a Howden-Johnson auxiliary boiler for port use. Electrical power for domestic services and auxiliary machinery is developed by two 1200kW, self-contained, epicyclic-geared turbo-generators and three 500kW diesel-driven generators

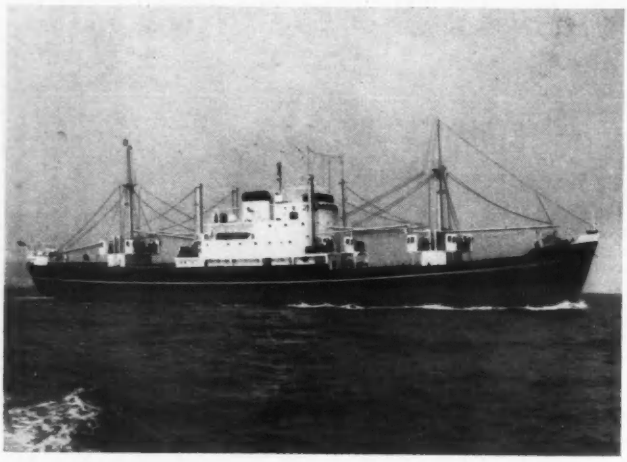




The liner "Reina del Mar," shown above, was completed by Harland and Wolff, Ltd., at Belfast, and joined the fleet of the Pacific Steam Navigation Company during the first half of the year. Accommodation is provided for 207 first-class, 216 cabin-class and 343 tourist-class passengers, and a crew numbering 327, and the ship has the following main particulars :—Length between perpendiculars, 560ft ; breadth moulded, 78ft ; depth moulded to "C" deck, 44ft, and gross tonnage, 20,225. Two Babcock and Wilcox controlled superheat, double-cased, divided-furnace, water-tube boilers burning oil fuel under Howden's forced draught, generate steam at 525 lb per square inch and 825 deg. Fah. for the main propelling machinery. This consists of two sets of Parsons triple-expansion turbines designed to develop a total ahead power of 17,000 s.h.p. when driving the propellers at 112 r.p.m. through double-reduction gearing. The electrical generating plant installed at the aft end of the engine-room consists of two 1000kW turbo-generators and three 500kW diesel-driven generators

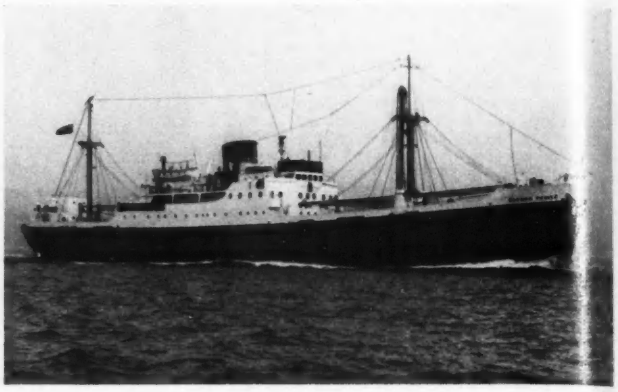
To the left is the Cunard liner "Carinthia," the third of four liners ordered from John Brown and Co. (Clydebank), Ltd., for the owner's Canadian service. The main particulars of the ship are : length overall, 608ft 3in ; breadth moulded, 80ft ; depth moulded to "A" deck, 46ft 3in ; draught loaded, 28ft 1in ; cargo capacity, 300,000 cubic feet ; gross tonnage, 21,946. Two classes of passengers are carried, there being 154 first class and 714 tourist class, and a crew of 461. A service speed of 19·75 knots is maintained by a two-set arrangement of double-reduction geared Parsons turbines, developing a normal power of 21,500 s.h.p. at 136 propeller revolutions per minute, and taking steam generated at 550 lb per square inch and 850 deg. Fah. by three Foster Wheeler E.D.S. boilers. Four 750kW, self-contained, geared turbo-generators on a flat at the aft end of the engine-room provide electrical power for the ship's services and auxiliary machinery

CARGO-PASSENGER AND CARGO SHIPS

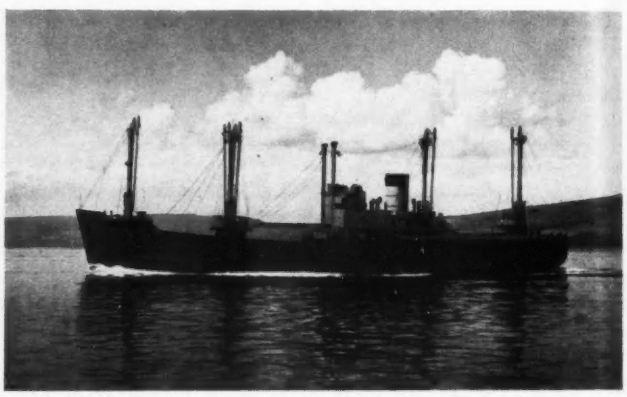


The raised quarter deck coastal cargo ship, "Burwah," was built for Australian Steamships Proprietary, Ltd., by the Burntisland Shipbuilding Company, Ltd., and designed to carry a deadweight of 3400 tons on the following dimensions: length between perpendiculars, 290ft; breadth moulded, 44ft 6in; and depth moulded, 20ft 10in. There are four holds fitted with sliding steel hatch covers and served by a complement of ten 5-ton and two 7-ton derricks. The deck machinery is all-electric and consists of twelve winches, a warping winch and a windlass, while the steering gear is electric-hydraulic. A British Polar diesel engine, having nine cylinders of 340mm bore by 570mm stroke and developing 1440 b.h.p., is the main propulsion unit and power for lighting and the engine-room auxiliaries is provided by four 100kW diesel-driven generators

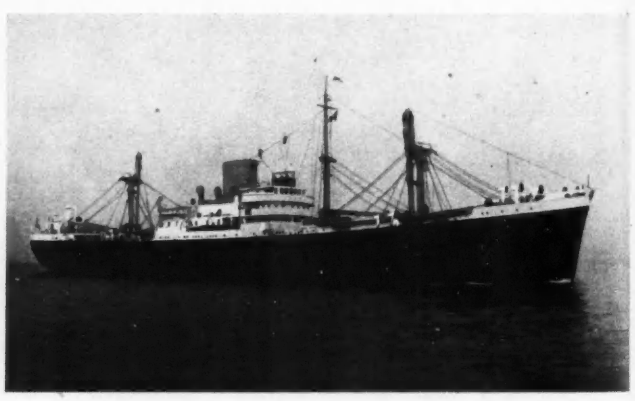
The Scottish Shire Lines took delivery of the cargo and passenger liner "Argyllshire" from the Greenock Dockyard Company, Ltd., for its service in the Australian trade. Cargo is carried in six holds and 'tween decks, providing 600,000 cubic feet of space, of which 378,000 cubic feet is insulated, and amounts to 11,250 tons on 28ft 3in draught. The main particulars of the ship are: length overall, 535ft; breadth, 69ft; depth, 41ft 7in, and a service speed of 16¾ knots. There are cabins for twelve passengers. For cooling the cargo there are three "Freon" compressors and for handling it there are one 105-ton, two 40-ton, four 15-ton, four 7-ton, and twelve 5-ton derricks served by twenty 5-ton electric winches. For propulsion purposes there is a set of triple expansion Parsons reaction turbines driving through double reduction gearing and developing a service s.h.p. of 10,500 at 112 propeller r.p.m., and a maximum of 11,550 s.h.p. at 115·5 propeller r.p.m. Two Babcock and Wilcox boilers supply steam at 415 lb per square inch and 750 deg. Fah., and four 300kW direct-coupled diesel-driven generators meet the demand for electric power



The Burntisland Shipbuilding Company, Ltd., completed the cargo passenger liner "Norman Prince" for the Prince Line, Ltd., and also a sister ship, "Northumbrian Prince." Twelve passengers are accommodated and the ship carries citrus fruit and refrigerated cargo from the Mediterranean in three holds served by one 25-ton and six 5-ton derricks operated by steam winches. On a draught of 19ft 4in the deadweight is 3440 tons and the main dimensions of the ship are: length between perpendiculars, 313ft; breadth moulded, 46ft 3in; depth moulded to shelter deck, 27ft 9in. Electric power is supplied by two 45kW steam-driven generators and the main propelling machinery consists of a three-cylinder Ailsa-Doxford opposed piston oil engine of 2300 b.h.p.

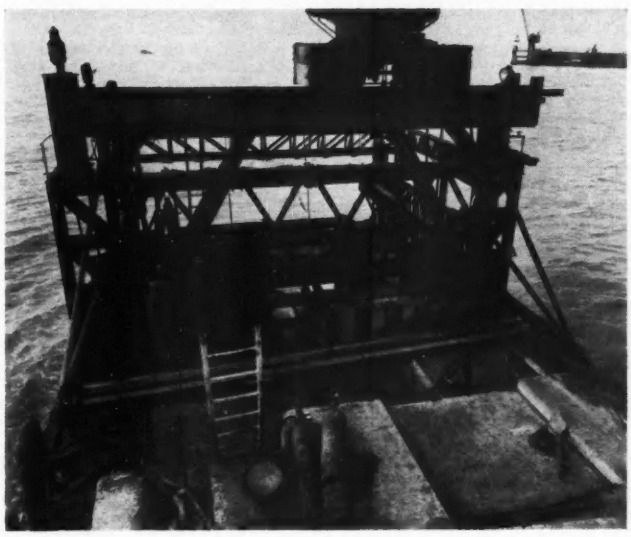


The "Kaituna," built for the owner's trade between New Zealand and Australia, was completed by Alexander Stephen and Sons, Ltd., for the Union Steam Ship Company of New Zealand, Ltd., and followed a sister ship, the "Kaimiro," completed earlier in the year. A deadweight of about 5300 tons is carried and the ship has a length of 325ft, a beam of 50ft, and a depth of 26ft. Large hatches allow for the carriage of bulk cargoes and are fitted with MacGregor steel covers while, for handling the cargo, there are twelve long-outreach derricks and one 25-ton derrick powered by electric winches. A single-acting six cylinder Stephen-Sulzer diesel engine propels the ship and develops 2410 b.h.p. at 128 r.p.m.



The cargo ship "Oti," which has a length between perpendiculars of 425ft by 62ft beam by 34ft depth to shelter deck, and a gross tonnage of 5485, was built at the Belfast yard of Harland and Wolff, Ltd., for Elder Dempster Lines. There are four main cargo holds and the cargo handling equipment includes sixteen derricks with lifts ranging from 3 tons to 12 tons, one 30-ton and one 80-ton derricks and fourteen electric winches. The ship is propelled by a Harland and Wolff two-stroke, single-acting, opposed piston diesel engine having five cylinders of 620mm bore by 1870mm combined stroke developing power at 115 r.p.m.

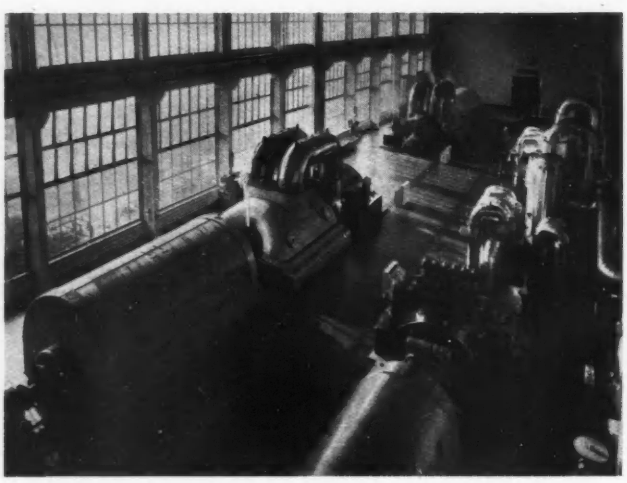
RECONSTRUCTION OF SHOREHAM HARBOUR

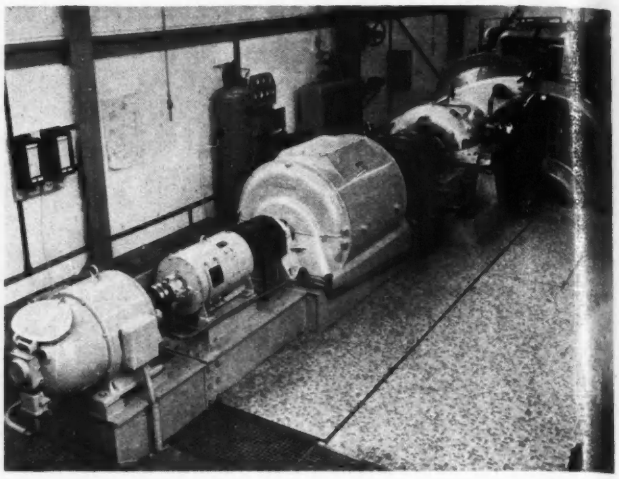


The harbour improvement works being carried out for the Central Electricity Authority at Shoreham, Sussex, and now nearing completion, include the provision of three new breakwaters ; the demolition, re-alignment and strengthening of existing structures ; the deepening and widening of the entrance channel between the breakwaters ; new sheet pile wharves and the construction of a lock 374ft long connecting the eastern arm of the harbour with the inner harbour. The whole project has been undertaken in order to admit colliers up to 4500 tons to the Central Electricity Authority's Brighton power stations. During 1956 particularly rapid progress was made on the breakwaters, which are of mass concrete construction between lines of steel sheet piling. On the two main breakwaters the contractor used a cantilever rig of his own design, which obviated the use of floating plant and temporary gantries ; it is illustrated on the right. The upper illustration shows work in progress on the east breakwater. The lock is also primarily of mass concrete construction, the walls being carried on vertical and raking steel box piles driven into the underlying chalk. Concrete was pumped through 6in pipes from a central weigh-batching and mixing plant, to the breakwaters or the lock, as required, the pumping distance being about 1600ft to the east breakwater and over 1000ft to the lock. Two 1 cubic yard mixers were used, which together produced about 62,000 cubic yards of concrete by the end of the year. A progress photograph, taken early in the year, is reproduced below, showing construction of the lock and lead-in jetties, with the dumpling being excavated from the lock, where struts are still in position

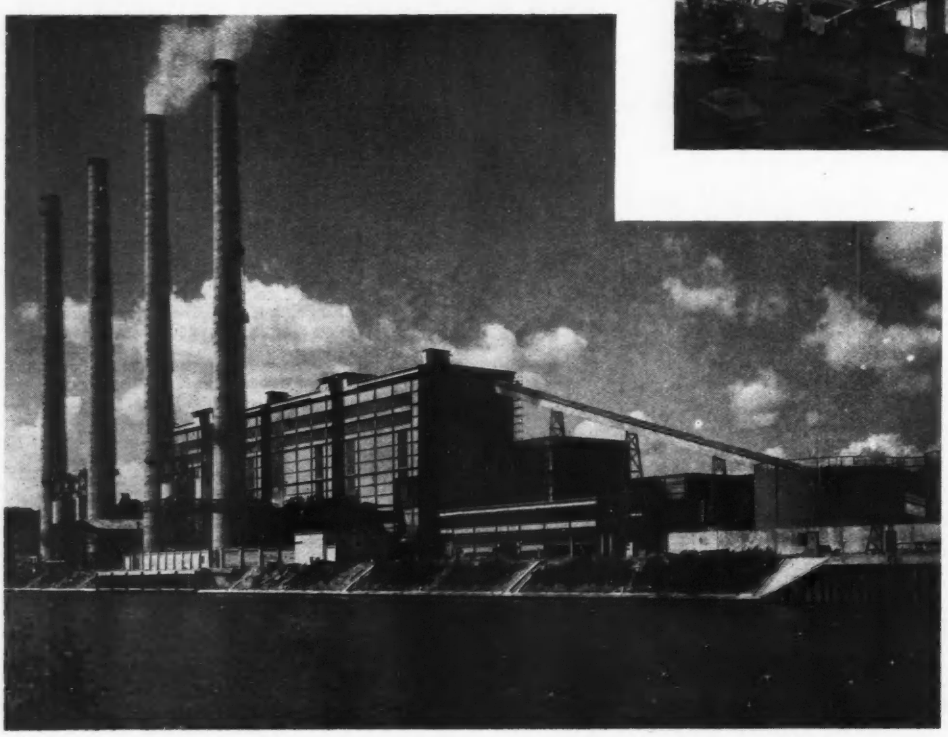
The lock was flooded in August, when all four lock gate leaves were stepped also. The gates, of welded steel construction, were towed from Thornaby-on-Tees to Shoreham. The heel posts and sill timbers are of greenheart, working in quoins and sills of Shap granite from Westmorland ; all machinery for the gates and sluice valves is hydraulically operated, the power being supplied by electrically driven pumps, one set on each side of the lock. Provision is made for emergency manual operation of gates and sluices. Dredging was carried on continuously in the western approach to the lock, where draglines and a suction dredger took material for the gravel washing plant feeding the central weigh-batcher. This was later taken over by the bucket dredger " Goliath," which started work in the harbour entrance channel in the autumn. Thus the final stage of the contract is well under way, and the whole should be substantially completed in the first quarter of this year. Main contractor, Peter Lind and Co., Ltd.; lock gates and sluices, Head Wrightson and Co., Ltd.; consulting engineers, Sir William Halcrow and Partners

CONTINENTAL POWER STATIONS



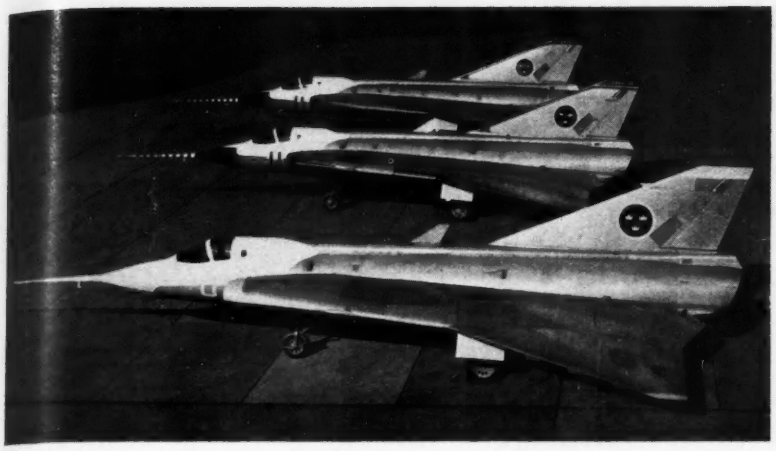


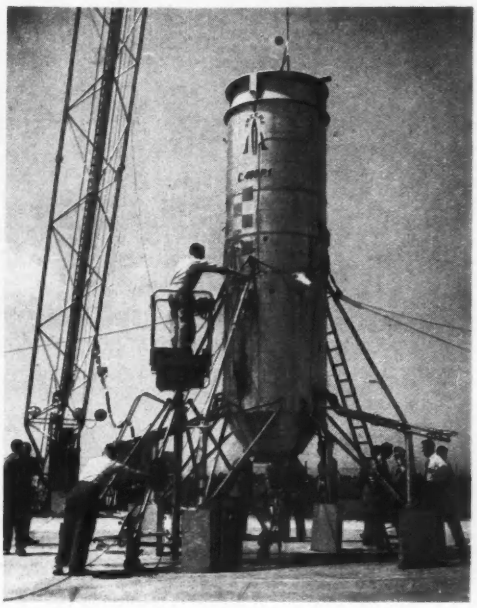
The "gradual" development of the steam turbine is well illustrated by Gersteinwerk power station at Stockum (River Lippe), shown above, which, with twelve sets of increasing size and a total capacity of 313MW, is the largest station of Vereinigte Elektrizitätswerke Westfalen A.G., successor to Elektrizitätswerk Westfalen A.G., founded in 1906. Begun in 1913, Gersteinwerk came into operation in 1917 with a 20MW, 350 deg. Cent., 13 atmospheres, set. Four extensions have taken place since then, steam conditions gradually increasing from 410 deg. Cent., 23 atmospheres, in 1924, and 510 deg. Cent, 125 atmospheres, in 1939, to 535 deg. Cent, 207 atmospheres, since 1952. Of particular interest were the first pulverised fuel boilers (130 tons per hour each), installed in 1927/28. In 1955, generation for the first time exceeded 1000 million kWh, compared with 9,000,000 kWh in the first year. Current is generated at 10kV, stepped up to 50kV and 110kV, or 220kV. On the right in the illustration are the high pressure sets ; on the left the intermediate and low-pressure turbines which operate with reheat from 280 deg. Cent. to 490 deg. Cent., and 30 atmospheres pressure. (Top, right) shows the 2MW air turbine set at Escher Wyss, Ravensburg, which reinforces an existing hydro-electric works plant, as well as supplying space heating up to 2·5 G cals. per hour. The plant can supply space heating up to 1000 kcal. per kWh without affecting either output or overall efficiency appreciably and is claimed to have a full load efficiency of 26 per cent (mean efficiency 22 per cent). Operating on a closed air cycle, the unit has a three-stage radial compressor and five-stage axial turbine mounted between two bearings. Inlet temperature is 660 deg. Cent., speed 12,750 r.p.m., reduced by a planetary gear. The double casing has an inner austenitic lining, with intermediate insulation. The load is adjusted by varying the system pressure, using an accumulator charged at 40 atmospheres by one Lysholm and one reciprocating compressor.



In order to reduce costs, power stations should be near the consumer. That they need not disfigure a town is proved by the station at Müller-strasse, Munich, shown above, where a 50MW A.E.G. set and 270 tons per hour boiler are installed. The power station at Creil-St. Leu, 40km N.E. of Paris, on the River Oise, is a 460/500MW station (four unit sets), the first of fifteen stations of similar capacity to be constructed in the Paris area in the next fifteen years, in order to allow an expansion of 7 per cent per annum. The four unit boilers at Creil are laid out for 360-400 tons per hour, 545 deg. Cent., and 96 atmospheres. Turbine inlet conditions are 540 deg. Cent., 89 atmospheres (540 deg. Cent., 16·7 atmospheres after reheat). Generation is at 15·5kV, stepped up to 63kV (one set) or 230kV (three sets). Coal can be discharged at 750 tons per hour (rail) and 150 tons per hour (barge).

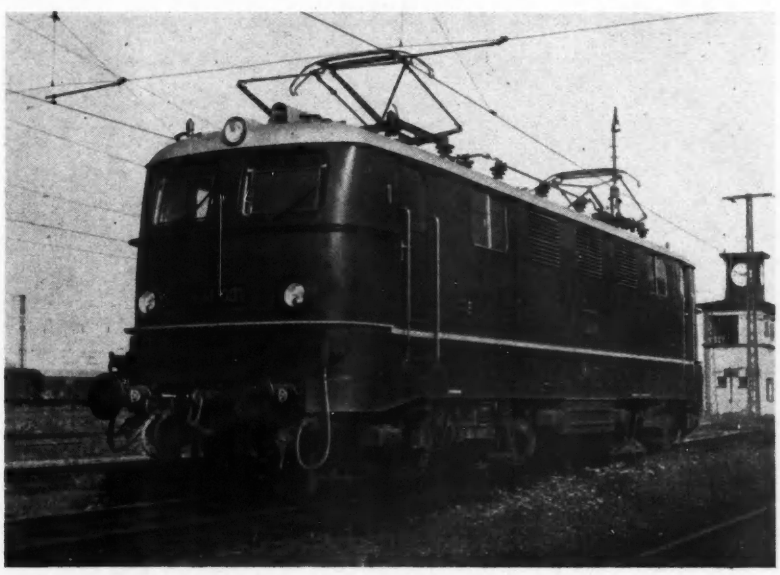
LAND, SEA AND AIR — CONTINENTAL DEVELOPMENTS





Our illustration (above) shows three prototype SAAB-35 (J-35 "Draken") supersonic jet fighters. This Swedish double-delta aircraft is now going into quantity production. Powered by a Rolls Royce "Avon" jet engine with afterburner, it has an all-up weight of 8-9 tons, depending on armaments. Preliminary work with the experimental SAAB-210 from 1950 onwards showed the advantages of the double-delta configuration. The duplicated hydraulic system, which includes full servo-controls, operates at the high pressure of 210kg per square centimetre. On the right we show the "Flying Atar" under its 35m test gantry at Melun-Villaroche. This radio-controlled wingless vertical take-off aircraft weighs 5600 lb ; its thrust in this case is limited to 6200 lb

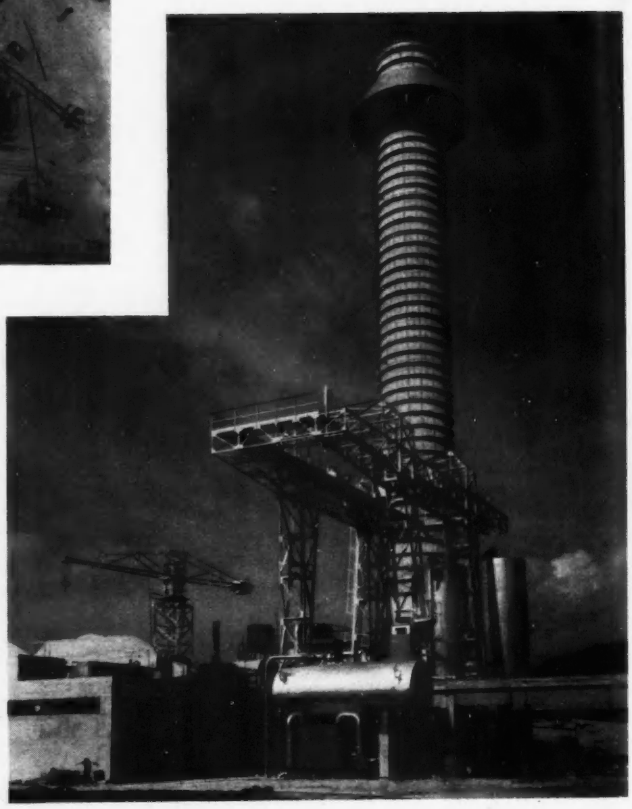
The "Gripen" (1680 tons gross) was built by Aalborg Værft A/S for Svenska Rederi-Aktiebolaget, Malmö, for the Malmö-Copenhagen ferry service. With a speed of 17 knots, she is equipped to carry 1500 passengers and ten vehicles. Propelling machinery consists of two ten-cylinder, two-stroke, single-acting "Polar" diesel engines developing 3800 h.p. at 300 r.p.m. Two reversible propellers controllable from the bridge are fitted. Built for navigation in ice, the ship has been specially reinforced. Electric welding has been extensively employed, and light alloys have been used for the superstructure to achieve the best possible stability. Navigational equipment includes radio wireless direction finding, projector compass, gyro-compass, and radar. An automatic telephone installation permits quick communication with the various departments on board and with shore exchanges

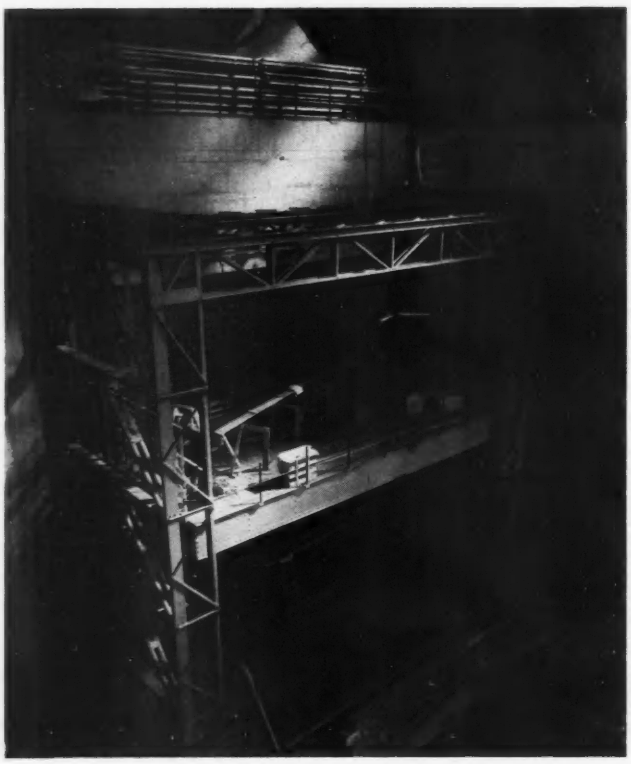


The first of the new "E41" electric locomotives came into service this year with the Munich Administrative Region of the German Railways. Built by Henschel and Sohn, Kassel, with electric equipment by Brown Boveri et Cie, Mannheim, the "E41" is laid out for a 15000V overhead supply at 16⅔ c/s. Its arrangement is B_o-B_o, and its weight, 66 tons. Each axle is individually driven by its own motor. At 70 per cent of the maximum speed, which is 120km per hour, i.e. at 84km per hour, the locomotive has an hourly rating of 2200kW, and a continuous rating of 2000kW ; length over buffers is 15·62m

FRENCH ATOMIC FACTORY AT MARCOULE

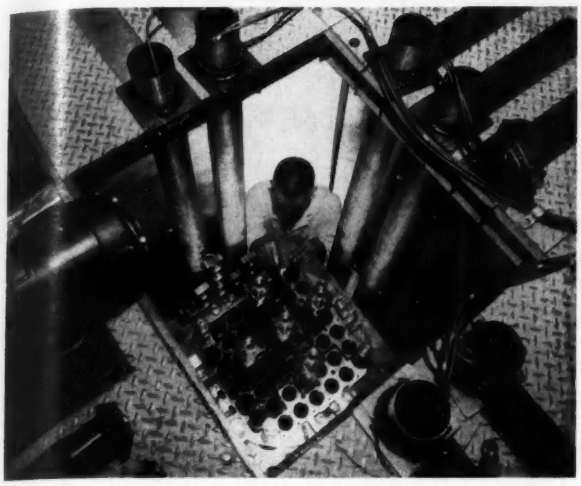
Construction of the Marcoule atomic centre has been in progress since 1954. Our illustration (left) shows the site of the G.1 reactor viewed from the 100m chimney, which itself is illustrated below. Although in fact G.1 is the first West European atomic power plant, its primary purpose is to produce plutonium. After eighteen months' work it came into operation on January 7, 1956, received its full charge of 100 tons of natural uranium in August, and began to produce power on September 28. Its thermal output of 40MW yields about 5·75MW of electricity, which is wholly consumed by the fans. The core contains about 1000 tons of graphite, arranged in a stack 9·6m in diameter by 8·84m high for a reflector thickness of 0·66m



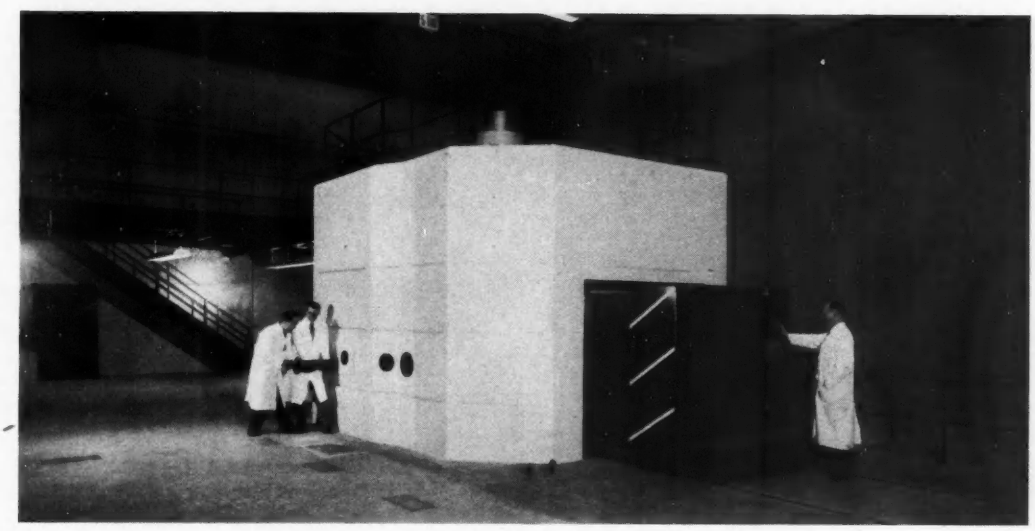


Cooling air is admitted by way of an 80mm central gap, which divides the pile into two halves, each with 1337 channels of 70mm diameter for the fuel elements. These are in the form of rods, 26mm in diameter by 100mm long, sheathed in magnesium and provided with spacer fins. Filtered air from 25m intake stacks passes through the 2600kW/5kV fans, each with a capacity of 80 cubic metres per second at 2500mm W.G. After precooling with water to 18 deg. Cent. the air is heated in the pile to 220 deg. Cent. About 31·5 million kcal/h are extracted by heating water to 200 deg. Cent. This is then piped (under 20 atmospheres pressure) to the three boilers of the turbine installation which supply the alternator set. In cases of power failure the reactor can be kept going for half an hour by supplying the total fan load of 8MW from the set, with the help of a hot water accumulator and using a static supply of cooling water. Charging and discharging of fuel is carried out from a control panel (top, right) by movable stages. The bottom left illustration shows the charging end of the reactor

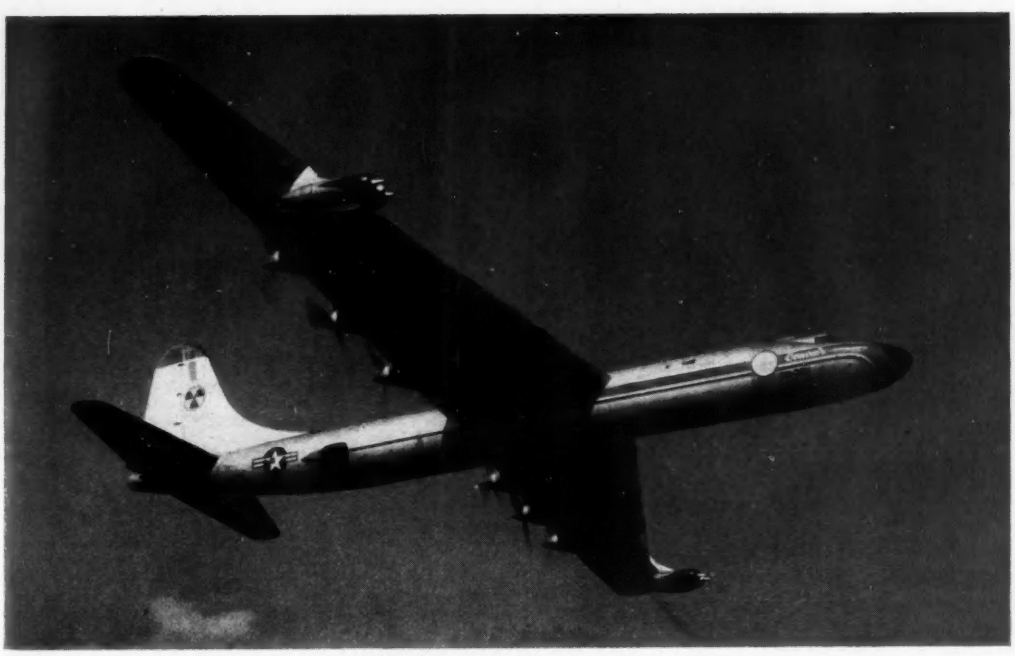
ATOMIC ENERGY DEVELOPMENTS IN THE UNITED STATES



The construction of the 1925kW U.S. Army package power reactor by Alco Products, Incorporated, is approaching completion, and the unit will go into operation early this year. The illustration shows the core of this pressurised water reactor undergoing criticality tests prior to final installation in the reactor proper. The entire plant has been designed so that its major components may be carried by air anywhere in the world and set up to generate electricity. The pile employs forty plate fuel elements of stainless steel and enriched uranium

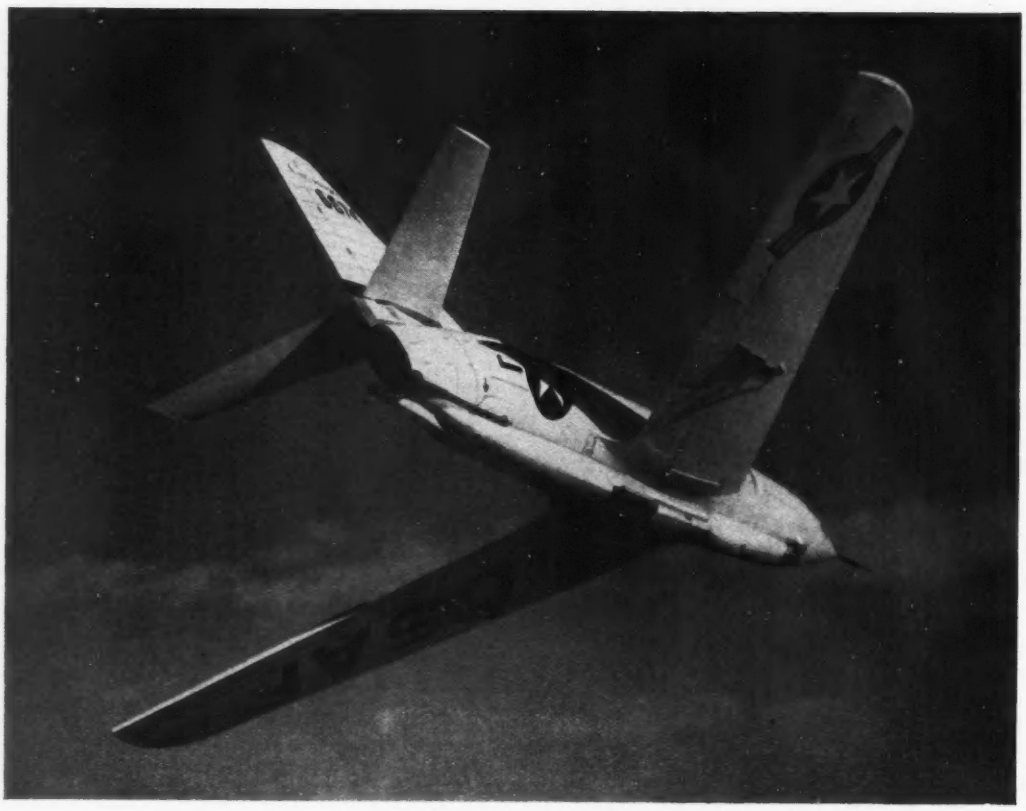


The 50kW homogeneous solution reactor built by the Atomics International division of North American Aviation, Incorporated, for the Armour Research Foundation in Chicago, went into operation in April, 1956. It is the first American nuclear reactor built particularly for private industrial research. The pile uses enriched uranium fuel dissolved in 4 gallons of water. The core is a steel sphere about 12in in diameter which is surrounded by an 8ft by 5ft by 5ft graphite reflector. Dense concrete, 5ft thick, forms the exterior shield. The unit can produce a maximum thermal neutron flux of $1{\cdot}7 \times 10^{13}$ neutrons per square centimetre-second

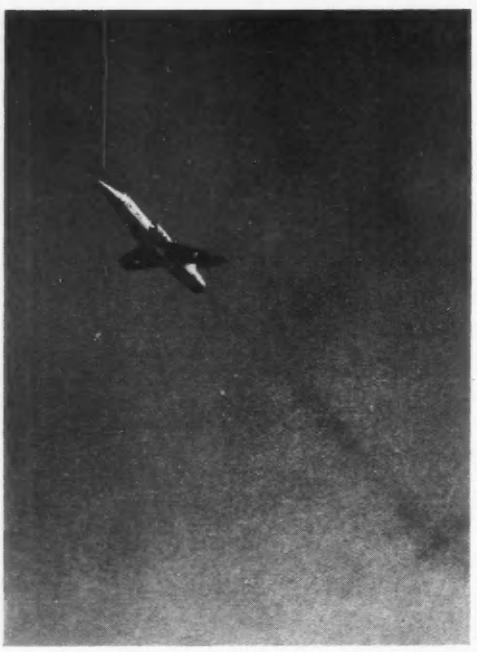


The "Convair NB-36H" inter-continental bomber is believed to be the first aircraft to fly with an operating atomic reactor aboard; it has been employed in carrying out research leading to the development of an atomic-powered aircraft. The aircraft has been making test flights over the south-western United States during the past year. On such flights the "hot" reactor does not power the "NB-36H." The low-powered reactor is never turned on until the aircraft is high over an unpopulated area, and then only to obtain data on airborne nuclear reactor operation. The effects of radiation upon instruments, equipment and the airframe are measured. Methods of shielding the aircrew, reactor operators, and electronic devices from radioactivity are tested and nuclear instrumentation is developed

SUPERSONIC AIRCRAFT



The highest and fastest flights by manned aircraft were performed by this Bell X-2 (above), which has reached an altitude of about 126,000ft. On September 27, the X-2 exceeded Mach Number 3—a speed of 2100 m.p.h. has been reported—but went out of control in a turn after exhausting its fuel. The machine fell from about 75,000ft to 45,000ft and then the pilot separated the nose "capsule" from the rest of the aircraft. The capsule fell under a parachute. The pilot jettisoned the cockpit canopy, but was killed when the capsule struck the ground with him within it. We show the X-2 on an early flight, with skids in place under the wings; it landed at about 180 m.p.h. The long fairing enclosing the pipes that carry fuel and oxidant back to the two-chamber Curtiss-Wright XLR-25 rocket motor of about 15,000 lb thrust can be seen, as can the exhaust of the pump turbines



The first flight took place in November last of the Convair B-58 "Hustler," supersonic airframe of a bomber-reconnaissance weapons system. The wing is a delta in plan and it can be seen that it is built with a high angle of incidence to give the needed angle of attack for relatively low indicated air speeds in the high altitude cruise case; notice that the fore part of the wing, over which the flow is subsonic, is cambered. The undercarriage also is typical of aircraft with this planform. The engines are General Electric J-79's, with several stages of variable-incidence stator blades in the compressor; centre bodies can barely be distinguished in the intakes. It is believed that, in the modern manner, the "Hustler" will carry its war load in a pod outside the main structure. These loads are supposed to include bombs, cameras, missiles, or even fuel for flight refuelling

A Lockheed YF-104 in flight (left), showing the variable geometry air intakes for which the "Starfighter" is noted. The conical centre body runs backward and forward to focus the inclined shock wave on the arc of the intake edge, positioned automatically to give maximum efficiency. This view emphasises the limited wing area, but with full-span leading edge and part-span trailing edge flaps the landing speed is reduced to about 160 m.p.h. In combat at supersonic speeds, times of engagements are exceedingly short, and high muzzle horsepowers are essential for gun armament to be successful: the "Starfighter" will attack with a six-barrelled "Vulcan" cannon firing 22mm shells at about 7000 rounds per minute. The gun works on the principle patented by Gatling, the cluster of barrels being rotated by an electric or hydraulic motor, and the ammunition is electrically detonated. It weighs about 300 lb; it is also used in the "Hustler" illustrated above

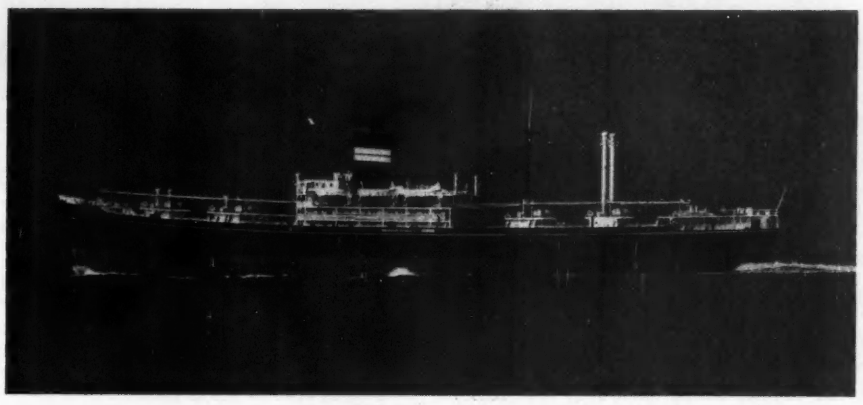
totals give an indication of the competitive strength of those countries, but factors affecting the placing of orders by foreign owners have changed. Both Germany and Japan now have a considerable backlog of orders, so that the advantage of earlier delivery has largely disappeared, as has also the ability to quote fixed prices, so that contract conditions in these respects more nearly approach those in this country.

Reference has been made already to the size of tankers, which class of tonnage dominated the order books of most countries. In Great Britain oil tankers represented 40·5 per cent of the ships under construction and the corresponding percentages for Japan, Germany, Italy, Netherlands and France were respectively 50·7, 51·8, 43·4, 31·5, and 49·5. Of the tanker tonnage building in the six countries mentioned, the percentage for export was 24·5, 93·4, 62·8, 36·0, 55·5, and 60·8 respectively. At the end of September the ships under construction in Great Britain were divided into the following main groups :—Passenger and passenger-cargo liners, 7·6 per cent ; cargo liners, 32·5 per cent ; cargo tramps, 9·3 per cent ; oil tankers, 40·5 per cent ; ore carriers, 5·9 per cent, the remainder being colliers, coasters and other small craft. These returns showed a small decline in passenger and passenger-cargo liners and a corresponding increase in tramps. A total of 2,329,000 tons of ships was stated to be preparing and this, added to those under construction, raised the total to 4,407,000 tons gross, the corresponding group percentages being 4·3, 25·7, 9·3, 52·0, 5·8. As already stated, these figures do not include the last quarter of the year, so that some adjustment may be necessary when the final totals are available.

Employment levels were maintained during the year with 60 per cent of those employed being engaged on new work and the rest on repair work. This section of the industry had an "output" exceeding in value £70,000,000, a total which could be raised with a little more steel plus better co-ordination of jobs and flexible labour conditions, such as those which obtain on the Continent. With the sharp challenge put forth by Japan for supremacy in shipbuilding, it is emphasised that a large order book is not the essential constituent of a prosperous industry, but rather the tonnage completed in any one year. The major role which adequate and "in sequence" deliveries of steel can play in expanding production has already been commented upon, but management and men also have a valuable contribution to make. Management must be keen and progressive and keep itself informed regarding new techniques and improvements on old ones, the development of machine tools and the availability and use of new materials. However, the most careful planning can have little success without the co-operation of the trade unions and their willingness to forego outmoded methods and to adjust rules to accommodate new techniques. The attitude of the unions also largely nullified the training and education received by apprentices in modern shipbuilding.

Mr. R. C. Thompson said something about labour problems in his presidential address to the North East Coast Institution of Engineers and Shipbuilders. He described as heartbreaking, the "walk out" or unofficial strike, the adoption of "work to rule" policy, the limitation of output, the embargo on overtime, the imposition of ridiculous conditions, and various other obstructions which make nonsense of organised production. Mr. Ormston, the managing director of Austin and Pickersgill, Ltd., also expressed concern at the reluctance of the unions to discontinue customs completely unrelated to modern conditions and their continued absorption in questions which were only of academic interest to-day, and many of which were unknown in countries which entered the industrial field at a later date than ourselves.

Then there was a number of demarcation disputes, culminating in the preposterous inter-union argument as to which should bore holes in aluminium sheets! It is time that the unions cut out the obsolescent, pruned the deadwood and grafted on the new, for they must be aware that the stoppages which so bedevil the industry mean that all are losers. They must also have knowledge that new shipyards are being built in other countries and that competition is growing in strength ; further, they should realise that a prosperous industry is based upon the interests of capital and labour being identical.



The cargo liner "Nyanza" was built and engined by Scotts' Shipbuilding and Engineering Company, Ltd., for the British India Steam Navigation Company, Ltd., and has a length between perpendiculars of 480ft, a breadth of 67ft 6in, a depth of 41ft 8in to shelter deck, and carries a deadweight of 10,220 tons on 27ft 7½in draught at an economic service speed of 17 knots. The gross tonnage is 8513, and the six cargo holds are served by a complement of twenty derricks. Two Babcock and Wilcox boilers supply steam at 478 lb per square inch gauge, and 750 deg. Fah., to a set of geared turbines developing a maximum service power of 10,250 s.h.p. at 116 propeller r.p.m., and 8500 s.h.p. at 110 propeller r.p.m. at economic speed. Power for auxiliary machinery is provided by three 300kW diesel-driven generators. A sister ship, the "Nardana," was built and engined by Barclay, Curle and Co., Ltd.

Taxation, flag discrimination, flags of convenience and the replacement problem continued to occupy the attention of shipowners during the year. The penal taxation which directly affects the ability of the shipping companies to replace ships was constantly attacked and shipowners continued to point out that they were in direct competition with world fleets, many of which were subsidised in a variety of ways, including flag discrimination. Furthermore, artificially stimulated national fleets only resulted in upsetting the shipping market and greatly added to the difficulties of shipowners in maintaining services. For several years the industry has said that it is unable readily to finance new building out of the profits remaining after being taxed, and that this is slowly coming to pass was made evident by the marked increase in the application for mortgage loans by shipowners. Another fact which could not be overlooked was that, although our merchant fleet was expanding, those of the rest of the world were expanding much more rapidly, with the result that our share of world tonnage has steadily declined from about 26 per cent before the war to about 19 per cent to-day.

Another movement which high lighted the twin difficulties of creating reserves for fleet replacement and of meeting competition was the rapid rise in the total tonnage registered in Liberia, where taxation is extremely low. Ships registered under such flags gain an enormous commercial advantage, which could threaten the present relationship between the fleets of the maritime nations and upset national economics. With little taxation to meet, owners of fleets registered under flags of convenience are easily able to accumulate financial resources to meet the cost of new building and ship replacement. To meet this threat to their very existence several British owners formed companies in Bermuda or the Bahamas, and there was every evidence that many other owners were considering the advisability of such a move in order to keep their fleets in being.

As was pointed out by the President of the Chamber of Shipping, shipping, unlike civil aviation, does not have large sums of Government money to spend on research and development, but must largely pay for its own research. Shipping must be flexible and accommodate itself to changing world trade if it is to continue to earn, by sales of its services, over £200 million in foreign currency. This point regarding the state-aided activity of civil aviation was remarked upon by Sir Donald Anderson in his presidential address to the Institute of Marine Engineers, when he commented that marine engines were not developed at the taxpayers' expense. He also, elsewhere, suggested that the Government should concentrate its attention on nuclear propulsion for ships in view of the dangers inherent in our dependence upon oil. In short, a little of the "feather bedding" accorded to the airlines would be of considerable assistance to shipping companies in maintaining and expanding their fleets, which are so essential to our trade and balance of payments.

(To be continued)

IMPROVEMENT ON A.5 IN STAFFORDSHIRE.—The London-Holyhead Trunk Road, A.5, is to be widened for a distance of 1¼ miles from its junction with A.38 to the village of Weeford, in Staffordshire, at an estimated cost of £94,000, it is stated by the Ministry of Transport and Civil Aviation. The scheme will provide for two traffic lanes and a passing lane within a 33ft wide carriage-way throughout the length of the section, and improvement of visibility. It has been prepared for the Ministry by Mr. F. Jepson, the county surveyor. The work is being carried out by Percy Bulton, Ltd., and has just started.

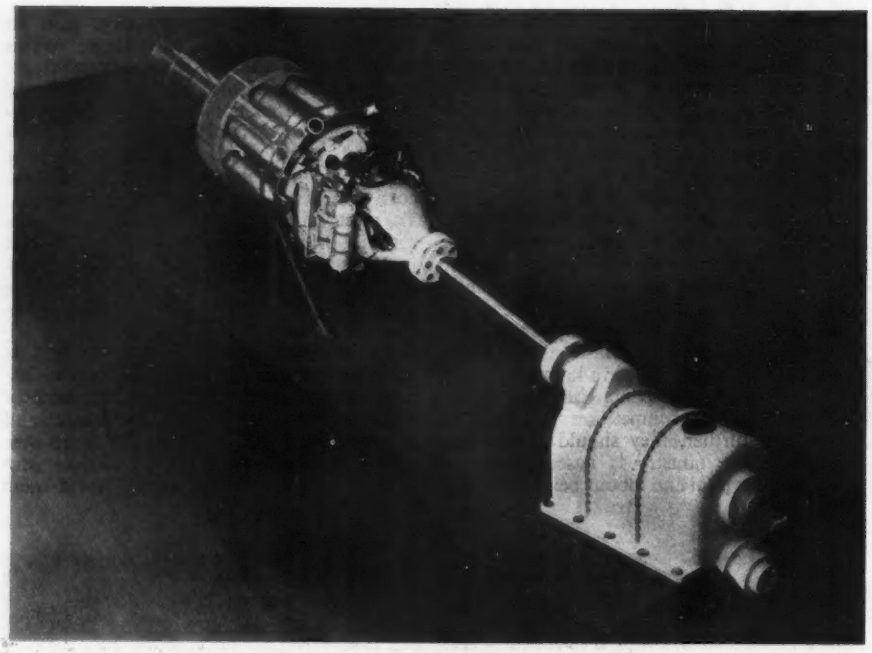


Fig. 1—A mock-up of the marine "Proteus," intended to power high-speed patrol boats. It will weigh 3000 lb and develop 3500 s.h.p.

Gas Turbines in 1956

IT is becoming clear that the progress of the gas turbine, particularly in industry, will not be fast enough for there to be important progress each year. In this annual article we shall not discuss at any length the industrial engine, merely recording that Ruston "TA" lightweight turbo-alternators were commissioned burning coal tar and, in Italy, natural gas, that most popular turbine fuel. Of the three 2500kW generators for the Metropolitan Water Board, that of Metropolitan-Vickers has not been used during 1956. The Brush plant is undergoing full-load trials, while the English Electric engine is carrying out test running in the maker's works. The power station at Dunston is now running its 15MW Parsons generator, and at the National Gas Turbine Establishment the 10MW alternator and the air bleed sets have both been commissioned. The Parsons turbine for the North British coal-burning locomotive is undergoing tests in the maker's works.

Meanwhile operation on residual fuels remains obstinately in the future.

Of the small turbines, the Budworth has now been matched with a water pump. In the apparently attractive vehicle application where the light weight and turbine torque characteristic would be most valuable, progress is slow and not in a promising direction. The advantages of the turbine would most profitably be utilised by a goods vehicle, whose transmission is heavy and costly and whose maintenance is done in precious time, but because of the prominence of fuel costs in operating expenses, the turbine is at present being tried in passenger cars. The long-awaited heat exchanger made its appearance on the Rover "T.3" at Earls Court in October, a compact recuperator being installed immediately above the engine in the rear of the car, in contrast to the regenerator of the General Motors "Firebird II." The Rover also gave a pointer to one of the remaining difficulties facing the designer, namely, response to the controls. Since a rear-engined car can achieve very high accelerations with only two wheels driven, it is clearly not for performance reasons that Rover has adopted four-wheel drive, but rather because the slow response of the turbine makes it impossible to avoid and difficult to control wheel spin.

The "T.3," however, is again described as an interim experimental model rather than a precursor of production versions, and the Austin and other engines are apparently no nearer service. While this may in part be due to the difficulties besetting the development engineers, it can hardly be hoped that scarce capital will be invested heavily in a new form of engine while fuel costs remain arbitrary and subject to violent fluctuation.

A pattern of engine that is drawing increasing interest is the free-piston gas generator turbine combination. A General Motors car with twin generators and a turbine, the XP-300, which is claimed to be able to run on oils of mineral, vegetable or animal extraction, last year crossed the Continental U.S.A. In Great Britain developments under Pescara licence are being handled by Meadows, and in this case are directed to heavy vehicle applications.

A new development last year was the Bristol "Marine Proteus," a model of which is seen in Fig. 1. Among aircraft engines the contest between light weight, on the one hand, and economy and reliability, on the other, is settled with widely differing emphasis in either direction, and the "Proteus," designed essentially for civilian operation in large aircraft of long range and with many engines, is strongly biased towards low loadings and long life. Thus it is inherently a suitable aero-engine for a marine conversion, though with no pretence to the cruising economy of such an elaborate plant as the Rolls-Royce "R.M. 60." The model shows the manner in which a "Proteus" might be installed in a high-speed launch, the exhaust opening directly towards the stern and the drive shaft running to a reversing reduction gear at the front of the propeller shaft. A "Proteus," it may be observed, is the prospective power plant for the land speed record challenger projected by Donald Campbell.

Aircraft Propulsion

In contrast to 1955, when several new variants of existing cycles appeared, 1956 saw little beyond new marks of existing engines and the emergence of one major problem besetting the "Proteus." Trials of Bristol "Britannia" aircraft intended for the "Springbok" route disclosed that the engines were liable to extinction in tropical thunderstorms. Storms such as are of everyday occurrence in South Africa may extend up to 50,000ft or even 60,000ft, and in the upper levels of the clouds water will be present in the solid state; the temperature being perhaps −50 deg. Cent., this is known appropriately as "dry ice." De-icing systems for normal flying are, of course, intended to counter the formation of ice from supercooled vapour, and are satisfactory if they maintain the surface of the machine above freezing point. Such ice formation is, as related in our columns on September 2, 1955, page 345, effectively countered on the "Proteus," the inlet guide vanes being heated

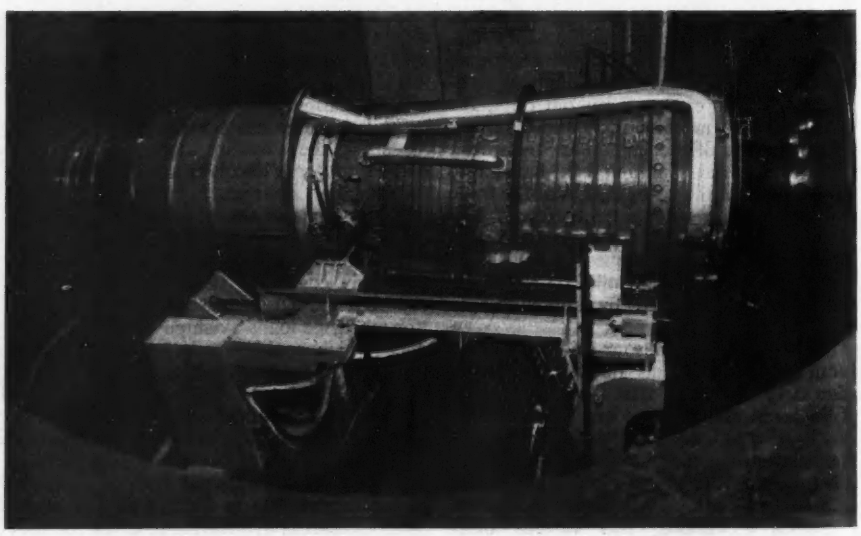


Fig. 2—A Bristol "Olympus" engine on test. The "Olympus 6," with a longer and larger compressor casing, has a thrust of 16,000 lb

by hot gas from the conveniently situated turbine. Water in the solid phase, however, may collect in some quantity in the rear end of the long annular duct leading to the compressor intake, the warmth of the engine melting the ice sufficiently to make it sticky; in a conventional engine, of course, the ice would be ingested by the compressor as quickly as it was inspired. The result was that water entered the engine suddenly in high concentrations, and the resulting abrupt fall in compressor delivery temperature extinguished one or more combustion chambers. This was obviously intolerable, since more than one engine might be affected simultaneously, while if the engine stopped icing of the intakes was liable to occur. An early remedy was to relight immediately, and a "glow plug" continuously alight in the combustion chambers has been introduced. A more subtle solution has been to gain some measure of control over the accumulation of ice, i.e. by momentum separation to remove it from the air stream entering the compressor and then melt it down. It is believed that consideration was given to the fundamental approach of extending the stability range of the combustion chamber by an oxygen lance; however, it is obviously undesirable to commit the engine at this stage to a fresh series of approval tests. Airliners with the modified engines will initiate the delayed service on February 1 this year.

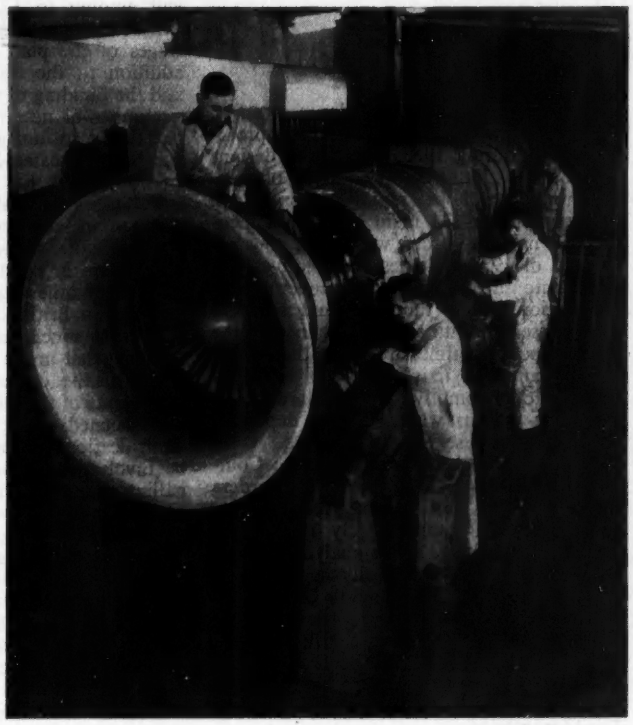


Fig. 3—Rolls-Royce "Conway RCo5," showing the extreme hub/tip diameter ratio of the first stage compressor blades

Meanwhile, one "Britannia" has been flight testing the successor to the "Proteus," the "Orion." This engine, having two axial compressors coupled to two turbines, h.p. to h.p. in the accepted manner, is of the "straight-through" pattern, and generally resembles the larger jet engines. The most powerful jet in Britain at present is a recently disclosed mark, the B.Ol.–6, of the Bristol "Olympus," seen in Fig. 2, which gives 16,000 lb thrust. This two-spool turbine is, of course, known for its high altitude performance, holding as it does an altitude record of 65,872ft, but it is noteworthy that a General Electric J.79 engine, with variable incidence blading in a single compressor, has climbed to over 70,000ft in U.S. fighters.

During the year more light has been shed on the relative merits of pure and by-pass jet engines. Various highly detailed studies have shown that a by-pass ratio of 50 to 60 per cent will involve a sacrifice of fuel consumption of about 2 per cent for otherwise comparable engines. To counter this, the by-pass engine will be lighter by perhaps 15 per cent, so that the relationship between power plant weight and fuel weight will determine the more economic engine. The by-pass engine will, of course, run at a much higher peak temperature and presumably sacrifice overhaul life, but over shorter sectors, which tend to be flown by smaller aircraft which can more easily spare the time for an engine change, this may not matter. On the other hand, an improvement in noise level and fire risk will make its strongest appeal to an operator executing frequent take-offs and landings. The principal by-pass engine of to-day, the Rolls-Royce "Conway" (seen in Fig. 3), is expected to power some of the Boeing "Jet Stratoliner" aircraft. It is not, at present, beyond dispute that the mighty MIK–209, of 17,500 lb thrust, and the derated version in airline service on the TU.104, are by-pass engines.

A further British engine which has been developed and type tested, but may not see service unless in an American aircraft, is the Napier "Oryx" turbo-gas generator, which was to have powered the Hunting Percival P.74 helicopter, the procurement of which by the Ministry of Supply has now been abandoned. Another single-shaft Napier engine may, however, establish itself as a helicopter power plant, since the "Eland" both drives mechanically the five-bladed rotor of the Westland "Westminster," a gas turbine version of the Sikorsky S.56 twin-engined helicopter, and also, in N.El.3 form, powers the Fairey "Rotodyne." "Eland" engines are now flying in a modified Convair-Liner, and it may be that this conversion will be incorporated in some of the many machines already flying or the "Metropolitan" models being built.

An engine of which there is still little known is the Rolls-Royce R.B.108. However, the fact that five of them power the Short S.C.1 vertical take-off aircraft suggests that it resembles the lightweight "Soar" turbo-jet, but with an improved fuel economy and extended life to allow it to be used for taxi-ing and cruising. The "Soar," it appears, will be yet another engine to find application only overseas; it is expected to propel a supersonic Radioplane drone target. Almost equally unknown is the D.H. "Gyron Junior," which was shown at the 1956 S.B.A.C. Exhibition. An engine of immense thrust, approaching 20,000 lb, is the Orenda "Iroquois," for which a Boeing "Stratojet" is to act as a test bed.

It is interesting at this date to recall that one of the earliest axial-compressor annular-combustor gas turbines still survives in the (originally Metropolitan-Vickers) "Sapphire." However, it may be that its far-reaching development programme is now nearing an end, for Wright J.65 engines are yielding place to the more ambitious G.E. J.79 in the U.S.A., and in this country Rolls-Royce "Avon" engines are to displace the Armstrong Siddeley units in all production P.1 fighters. Since "Olympus" jets were proposed for the high-performance version of the Gloster "Javelin," it may be assumed that the "Sapphire" will be confined to service in subsonic aircraft.

An engine which may for convenience be studied under the heading of "gas turbines," although the turbine rotor has been replaced by an aircraft in high-speed flight, is the ramjet. The existence of the Bristol "Thor" was disclosed after it had been developed into a fully reliable power plant for missiles. Few details are available beyond those shown in Fig. 4, and in a film showing it in action viewed from the nose of a vehicle on the flanks of which two "Thor" units were mounted. A two-shock intake leads to an annular combustion chamber, where burning is initiated by flares which are ignited when the missile is fired. Fuel supply, once the engine is running, is by ram-air-driven pumps. At the nozzle a small contraction brings the gas stream up to and beyond supersonic velocities: this nozzle is cooled by air taken in through the ring of holes seen on the outside of the duct and leaves through the narrow annular gap at the tail. The performance of the "Thor" is not at present known, but may be about 10,000 lb thrust at Mach 2. While Napier has built for test by N.G.T.E. a low-supersonic athodyd with pitot intake, there is at present no British subsonic ramjet such as power some light and simple helicopters.

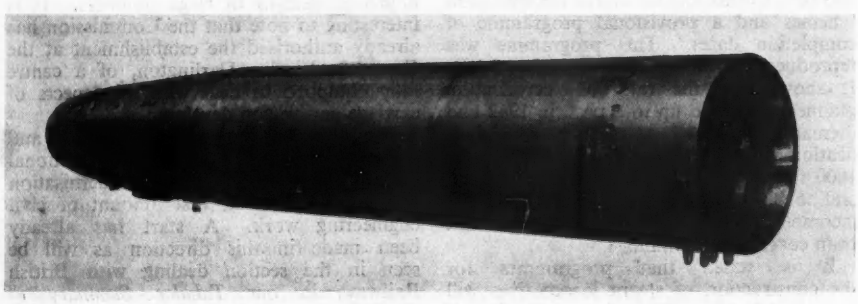


Fig. 4—A Bristol "Thor" ramjet, showing the air-cooled nozzle. Some details of the connections to the vehicle can be seen; the electric leads presumably ignite the pyrotechnics that light the combustion chamber

British Railways in 1956

IN looking back over the past twelve months it is evident that significant progress was made with the overall plans for the £120 million modernisation scheme for British Railways. This was borne out by the White Paper, "Proposals for British Railways," issued at the end of October, and the Transport (Railway Finances) Bill, under which the British Transport Commission has been authorised to borrow up to possibly some £250 million from the Consolidated Fund over a limited term of years. This loan, upon which a commercial rate of interest is payable, will be repaid by instalments after the expiry of a specified period. It will enable the modernisation plan to be pressed forward, and further progress made towards increased productivity by mechanisation and work study methods, both of which have already begun to yield results on British Railways. In this way it is anticipated that the railways will become more economical to operate, so that they will eventually yield earnings fully capable of meeting all charges, and the interest and repayment charges on the money borrowed. Under estimates given in the White Paper the accounts of British Railways should be approximately in balance by 1961 or 1962 and by 1970 the overall annual profits are expected to be about £50,000,000.

In the early part of the year two important announcements were made in connection with the modernisation programme: first, that it is proposed to adopt alternating current at 25kV and 50 cycles as the standard for future electrification and, secondly, that the vacuum continuous brake will be fitted on all freight rolling stock. It was announced at the same time that the first line to be electrified will be between Manchester and Crewe and that this section will be used as a proving ground for new equipment. The proposed a.c. system will be used for 1210 of the 1460 route-miles which are to be electrified on British Railways. The main trunk lines involve a total of 820 route-miles: Euston, Manchester, Liverpool; King's Cross, Doncaster, Leeds and possibly York; and Liverpool Street, Ipswich, in extension of the existing electrification which will be converted from 1500V d.c. to 6·6kV a.c. Similarly a.c. will be used for suburban electrification (excluding extensions on the Southern Region) totalling 390 miles: London, Tilbury and Southend; Liverpool Street, Enfield and Chingford; Liverpool Street, Hertford and Bishop's Stortford; King's Cross and Moorgate to Hitchin and Letchworth, including the Hertford loop.

The White Paper gave some interesting details of the preliminary programme which had been worked out for all the electrification schemes and a provisional programme of completion dates. This programme was reproduced in our issue of November 2 last. It shows that the rate of electrification planned will build up to a peak in 1962 and thereafter decrease. At the peak of electrification it will be necessary to commission 1000 miles of electrified single track a year, and to place in service at least 200 electric locomotives and 900 electric multiple-unit train coaches per annum.

It is stated that programmes for the construction of steam locomotives will be completed in 1958, after which few, if any, steam locomotives will be built for British Railways. It is expected that electric locomotives, now in the development stage, will be supplied in small numbers in prototype form during 1958. After the designs have been finally settled production of these locomotives will be rapidly stepped up. Delivery of the 174 main line diesel locomotives now on order will begin towards the end of 1957 and these locomotives will be put into intensive operation, under careful observation, for a thorough and selective trial. Essential data will be obtained in the shortest possible time to enable the Transport Commission to place orders for large numbers of locomotives in standard types, specifying designs which can be depended upon to give the service they require. Until these trials have been completed, the Commission intends to restrict further orders for diesel main line locomotives to comparatively small numbers. By 1961, however, it is expected that annual orders will reach a level of about 200 locomotives and that this rate of production will be required to continue each year for an indefinite period. A locomotive development centre which is to be set up at Derby will be organised to initiate development and study the technical performance, efficiency and economy of diesel locomotives.

The number of diesel shunting locomotives in service will be increased to 900 on completion of the authorised programmes in 1958, and the plans provide for the use of about 1600 diesel shunters in service by 1962. Multiple unit diesel vehicles have already proved their value in passenger service in many parts of the country and the modernisation plan envisages no less than 4600 vehicles of this type being placed in service. Contracts placed for 2401 multiple unit diesel coaches are expected to be completed in 1958, and it is anticipated that the remainder of the 4600 contemplated will be in service before the end of 1961.

The extensive introduction of electric and diesel traction will naturally necessitate a considerable amount of training of drivers and other staff and a number of schemes have already been initiated. Further, although the Transport Commission will rely upon outside industry for the supply of diesel and electric power equipment, it is proposed generally that maintenance work will be carried out in British Railways' workshops to the extent of their capacity. For this reason, maintenance staff training has already started and a number of new depots for the maintenance of diesel multiple-unit trains have been authorised in various parts of the country.

Complementary plans have been prepared for the development and introduction of carriages, wagons and other rolling stock of improved designs in large numbers. It is interesting to note that the Commission has already authorised the establishment at the Faverdale Works, Darlington, of a centre fully equipped to deal with all aspects of carriage and wagon development.

The electrification of the railways and other buildings, structural and constructional work associated with the modernisation plans will involve a vast amount of civil engineering work. A start has already been made in this direction as will be seen in the section dealing with British Railways in our *Tabular Summary of Civil Engineering Contracts*, in the issue of December 21 last. It is expected that the annual expenditure on this side of the plan will amount to £25,000,000 by 1959, and will be maintained at this rate until the later stages of the plan have been reached. In addition to the track and structural work and the building of new maintenance depots, a number of new marshalling yards are to be laid down and already over £14,000,000 has been allocated for these yards. Reconstruction work has been authorised and in some cases started at several important stations, including those at Cannon Street, Plymouth, Peterborough and Banbury, and designs are in hand for the rebuilding of a number of other stations. For many years stations on British Railways have been the subject of much criticism, and it is to be expected that under the modernisation plans many of the causes for the long-standing complaints of travellers will be removed.

Associated with the overall scheme of electrification and modernisation there will be involved a considerable amount of signalling and telecommunication work. The cost of this work will, it is expected, reach £12,000,000 a year by 1958, and continue at that rate for an appreciable time. As the lines are electrified resignalling will be carried out, with the provision of track circuiting and replacement of semaphore signals with a larger number of colour light signals. Following extended tests an approved system of automatic train control is to be introduced. This system will eventually be introduced on all main traffic routes, but will be installed initially on the following routes: London (King's Cross) via Newcastle to Edinburgh; London (Euston) to Glasgow (including Manchester and Liverpool); Edinburgh to Glasgow; London (Waterloo) to Bournemouth and Exeter; and London (Liverpool Street) to Norwich. This new A.T.C. equipment is designed for use with vacuum braking but it is stated that it can be adapted for the Westinghouse system.

On December 31 the Eastern Region started a through electric service between Liverpool Street and Southend-on-Sea (Victoria). This marked the completion of the £2,500,000 electrification scheme for the Region's Shenfield-Southend-on-Sea (Victoria)-Chelmsford lines, of which the Chelmsford section was put into service on June 11, 1956, and formed an extension of the Liverpool Street-Shenfield electrification completed in 1949. The whole of this electrification operates on the 1500V d.c. overhead system, but provision has been made to convert the system to the 25kV, 50 cycles, a.c. system. It is provisionally planned to electrify the Colchester, Clacton and Walton branches of the Region in 1958 on the a.c. system, and convert the Liverpool Street-Chelmsford and Southend lines to a.c. in 1959.

In an address to the Royal United Services Institution early last year, Sir Brian Robertson, chairman of the British Transport Commission, speaking of the modernisation plans, said "This great transformation, a second railway revolution which will far exceed even what the French Railways have achieved since the war, will take all of fifteen years to accomplish. It will only be accomplished within that time if successive Governments continue to give it their full backing and provided we get the response we hope from our industrial suppliers. Of course, during these fifteen years improvement will build up progressively, slowly at first and rapidly later on." From the work now in hand and the plans outlined in the White Paper it is evident that at least a promising start has been made, and for the next few years it will be interesting to watch these plans coming into effect.

Naval Construction in 1956

By RAYMOND V. B. BLACKMAN

No. I

Great Britain: Frigates

THE only highlight of new construction in this country in 1956 was the completion of the first big post-war frigates. These, with a number of other new units in various stages of construction during the year, were part of the naval rearmament programme initiated in 1950. Subsequently a total of twenty-six new frigates were ordered, and these were of four separate types. Six were of the 1st Rate or "quality" anti-submarine type named after seaside resorts and known officially as the "Whitby" class or "Type 12"; twelve were of the 2nd Rate or "utility" anti-submarine type named after famous naval captains of the past and officially known as the "Blackwood" class or "Type 14"; four were of the anti-aircraft type named after big cats and officially known as the "Leopard" class or "Type 41" (another of this class under construction was transferred to Indian Navy jurisdiction); and four were of the aircraft direction type, named after cathedral cities and officially known as the "Salisbury" class or "Type 61."

To these must now be added seven more frigates of these classes which were provided for under the 1956–57 Navy Estimates, namely, two of the "Whitby" class, three of the "Blackwood" class, one of the "Leopard" class, and one of the "Salisbury" class. In addition to these highly specialised frigates, eight general purpose frigates capable of carrying out the main escort functions of anti-submarine protection, anti-aircraft barrage and aircraft direction were projected under the 1955–56 Navy Estimates, and three more vessels designed to fulfil economically all the functions demanded of frigates rather than to have an outstanding performance in any one specialised role, are being ordered under the 1956–57 Navy Estimates.

But with our now acute shortage of cruisers (there are only twenty cruisers in the Royal Navy compared with the sixty we had at the end of the second world war), the need has arisen for a type of fleet escort superior to both the destroyer and the frigate categories and combining the functions of both with the leader and communications command qualities of the light cruiser. Accordingly, two fleet escorts, bigger than the "Daring" class, which will embody all the newest developments in the destroyer field, were provided for under the 1955–56 Navy Estimates, and it was recently announced officially that it has now been found possible to design these vessels with a guided weapon instead of with anti-aircraft guns. This will very greatly increase their fighting power. They will also carry a very modern anti-submarine armament, the latest radar equipment and excellent communications gear. Two more fleet escorts of this super-destroyer or squadron leader type are being ordered under the 1956–57 Navy Estimates.

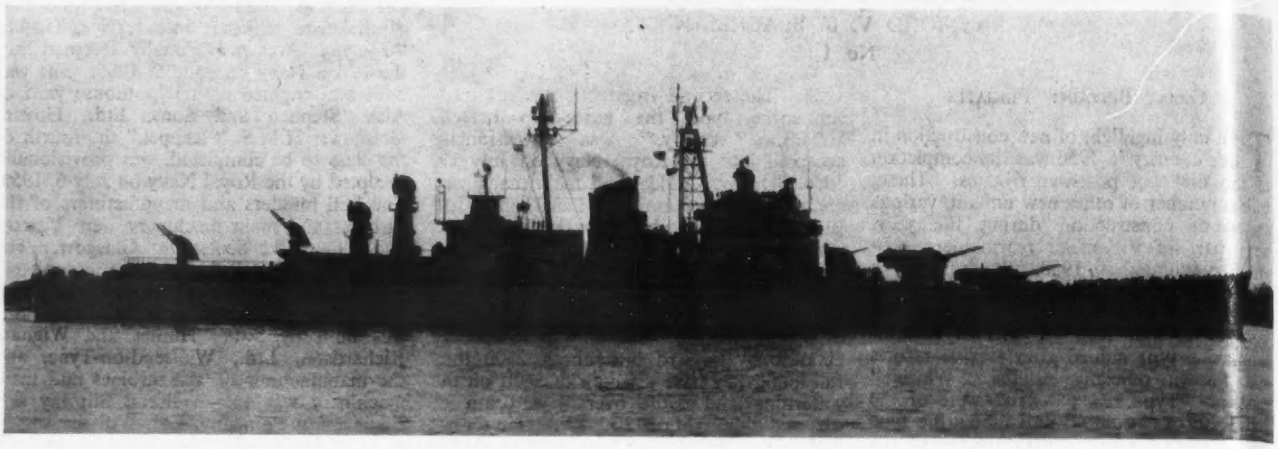
H.M.S. "Torquay" (see page 30), the first ship of the "Whitby" class 1st Rate anti-submarine frigates to be completed, was provisionally accepted into H.M. service on May 8, 1956. She was the first large and fast frigate designed as such for the Royal Navy. She was built and engined at the Belfast yard of Harland and Wolff, Ltd., where she was launched on July 1, 1954. The second frigate of the fast anti-submarine type, the name-ship herself, H.M.S. "Whitby," was provisionally accepted into the Royal Navy on July 19, 1956. The hull builder and main machinery contractor was Cammell Laird and Co., Ltd., who launched her from the Birkenhead yard on July 2, 1954. The frigates of this class were designed primarily as anti-submarine vessels, but they are also equipped for limited anti-aircraft defence. With an estimated displacement of approximately 2000 tons standard and about 2800 tons full load, they have a length of 360ft on the water-line and 370ft overall, a beam of 41ft and a draught of 12ft. With twin screws and twin rudders, they have a main engine plant comprising two Babcock boilers and two sets of geared turbines. The turbines of the "Torquay" and "Whitby" are officially stated to have been built to a design by the English Electric Company, Ltd. There are two shafts developing an aggregate of 30,000 s.h.p., equal to a speed of approximately 30 knots. The ships have a comprehensive armament which includes two 4·5in guns in a twin turret before the bridge mounted a deck below, just before it rises in a hump to a high weatherly forecastle; two 40mm Bofors anti-aircraft guns in a twin-barrelled mounting just abaft the diminutive mainmast lattice; and no fewer than twelve 21in torpedo tubes disposed in two twin and eight single fixed anti-submarine mountings, provision for which is made one each side just abaft the foremast amidships. The anti-submarine armament consists of two "Limbos." These weapons, which are mounted *en echelon* in a deep well aft which opens on to the quarter deck, can be trained over a wider arc than any previous types of anti-submarine mortars. The ships are fitted with the latest equipment for locating and hunting submarines, including facilities for directing anti-submarine aircraft. They are highly manœuvrable, and the hull form has been designed to enable them to maintain a high speed in heavy seas during submarine search. Of all-welded construction, they have been prefabricated in such a manner as to allow for rapid construction.

H.M.S. "Dundas" (Fig. 1), the second of the "Blackwood" class 2nd rate anti-submarine frigates to be completed, was provisionally accepted into naval service on March 16, 1956. The hull builders and manufacturers of the turbines and main machinery were J. Samuel White and Co., Ltd., Cowes, Isle of Wight. The third ship of the class to come into service, H.M.S. "Murray," was provisionally accepted into the Royal Navy on June 5, 1956. She was built and engined at the Linthouse yard of Alex. Stephen and Sons, Ltd., Govan, Glasgow. H.M.S. "Keppel," the fourth of the class to be completed, was provisionally accepted by the Royal Navy on July 6, 1956. The hull builders and manufacturers of the turbines and main machinery were Yarrow and Co., Ltd., Scotstoun, Glasgow. The fifth ship of the class to be completed, H.M.S. "Pellew," was provisionally accepted into naval service on July 26, 1956. She was built by Swan, Hunter and Wigham Richardson, Ltd., Wallsend-on-Tyne, and the manufacturer of the turbines and main machinery was the Wallsend Slipway and Engineering Company, Ltd. All the vessels of the "Blackwood" class have an estimated displacement of approximately 1300 tons standard and about 1700 tons full load with a length of 300ft between perpendiculars and 310ft overall, a beam of 33ft and a draught of 10ft. The armament consists of three 40mm Bofors anti-aircraft guns and two "Limbo" mortars of the same kind as those fitted in the larger "Whitby" class frigates, and provision was also made in the design for four 21in torpedo tubes in two twin mountings to be installed, although these have not yet been fitted. The propelling machinery comprises Babcock boilers and one set of geared turbines of an advanced design, standard with those in the "Whitby" class, turning a single screw and developing 15,000 s.h.p., equal to a speed of 24 knots. These new utility frigates are of somewhat unorthodox appearance with a very simple gun armament. Instead of the traditional sheer sweeping in a shallow curve up to the bows there is a steeper rise from the forward superstructure to the breakwater and then a high-level forecastle surmounted by a bulwark extended to the eyes of the ship. The ships appear to be decidedly undergunned, one Bofors being mounted right aft on the quarter deck and the remaining two on each side of the forward superstructure abreast the the foremast, and as there is no weapon on the forecastle at first sight they seem to be entirely gunless. These new frigates are, of course, designed purely and simply as anti-submarine vessels.

Two of the novel anti-aircraft frigates were completed at the end of the year. H.M.S. "Puma" (Fig. 2), launched from the Greenock yard of Scotts' Shipbuilding

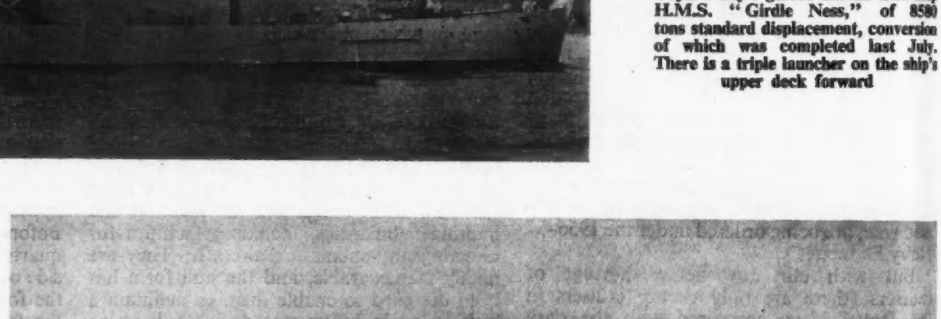
Fig. 1—H.M.S. "Dundas," completed March 16, 1956. New anti-submarine frigate (2nd rate)

NEW AND CONVERTED WARSHIPS



The United States heavy cruiser "Canberra," of 13,600 tons standard displacement, has been converted for firing guided missiles; she was commissioned in her new capacity on June 15 last. The "Canberra" and her sister ship "Boston" are the first operational vessels of their kind. The illustration above shows the firing equipment—two twin mountings for "Terriers" aft—tracking apparatus, and so on, installed on the converted ship. On the left we illustrate the Royal Navy's guided missile trial ship H.M.S. "Girdle Ness," of 8580 tons standard displacement, conversion of which was completed last July. There is a triple launcher on the ship's upper deck forward

New vessels commissioned by the Royal Navy in 1956 were, generally, limited to small vessels such as frigates and escort ships. However, the experimental submarine "Explorer" (right) was commissioned last May. She has a displacement of about 1000 tons submerged, diesel-electric and hydrogen peroxide propulsion plant, and is designed for high underwater speeds. We also illustrate the anti-submarine frigate "Torquay" (below left), and a destroyer escort of the Canadian Navy, H.M.C.S. "Assiniboine" (below right)



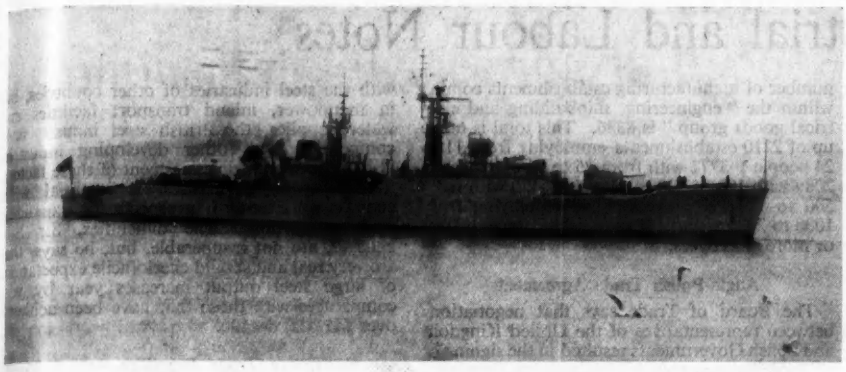


Fig. 2—H.M.S. "Puma," on trials 1956. New anti-aircraft frigate

and Engineering Company, Ltd., on June 30, 1954, was on trials in May, 1956; and H.M.S. "Lynx," which took the water from the Clydebank yard of John Brown and Co., Ltd., on January 12, 1955, has been preparing to commission for service since August, 1956. At the time of writing neither ship has actually been accepted into the Royal Navy from the builders. These new diesel-powered frigates were designed primarily for the protection of convoys against aircraft. They will also serve in lieu of destroyers in offensive operations, though they have not the high speed of destroyers and have no torpedo armament. The ships are all-welded. The displacement as designed was 1738 tons standard and 2185 tons full load, but as is so often the case with prototype ships, they are turning out some 10 per cent heavier than this. With a length of 330ft between perpendiculars and 340ft overall, they have a beam of 40ft and a draught of 12ft. They are armed with four 4·5in guns in two twin turrets disposed one forward in "A" position and one aft in "X" position; two 40mm Bofors anti-aircraft guns in a twin mounting high up in a commanding "Q" position just abaft the mainmast; and a "Squid" type triple-barrelled anti-submarine depth charge mortar aft in "Y" position. They look, and are, powerful and well-balanced warships. The 4·5in gun mountings and the gunnery control arrangements are similar to the main armament installed in the "Daring" class ships ordered during the second world war and built in 1945–54. The propelling machinery of the "Big Cats" consists of Admiralty Standard Range I heavy oil engines coupled to the propeller shafting through hydraulic couplings and oil-operated reverse and reduction gearboxes, turning two shafts and developing 14,400 b.h.p., equal to a speed of approximately 21 knots. The diesels of the "Puma" were manufactured by H.M. Dockyard, Chatham, and British Polar Engines, Ltd., Glasgow, and of the "Lynx" by Crossley Bros., Ltd., Manchester, and British Polar Engines, Ltd.

H.M.S. "Salisbury" (Fig. 3) entered the Royal Navy with a triple first. She was the first of the new aircraft direction frigates of the "Cathedral City" class, she was the first of all the twenty-six new construction frigates of the post-war rearmament programme to have been launched, and she was the first ship to be built in H.M. Dockyard, Devonport, since the second world war. The "Salisbury" was laid down on January 23, 1952. She took the water on June 25, 1953, and she was commissioned for service on October 22, 1956. She is the name-ship of the new class. Her main machinery manufacturers were Vickers-Armstrongs (Engineers), Ltd., Barrow-in-Furness. The construction of these aircraft direction frigates, an entirely new type in the Royal Navy, is all-welded and largely pre-fabricated, and they have highly developed electronic equipment for their very specialised role. They have much the same displacement as the anti-aircraft frigates of the "Leopard" class, although here, again, they turn out considerably heavier than at first estimated, and similar dimensions. They also have the same hull form and wale line, and similar Admiralty standard diesels of the same power and speed. They are not so heavily armed, but they carry a great deal more radar and

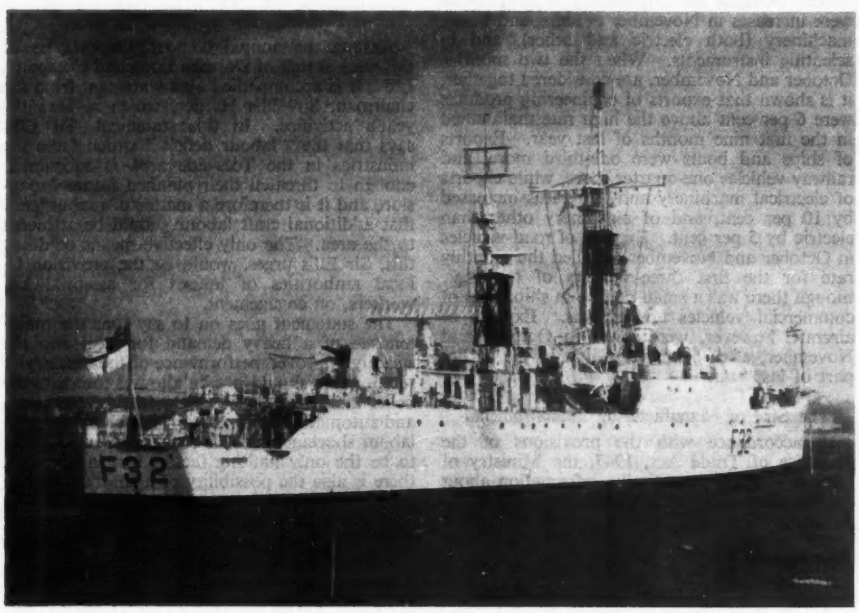


Fig. 3—H.M.S. "Salisbury," completed October 22, 1956. New aircraft direction frigate

associated equipment. They have only two 4·5in dual-purpose guns and these are mounted in a twin turret before the forward superstructure, and the two 40mm Bofors anti-aircraft guns are in a twin mounting aft in "X" position. The squid triple-barrelled anti-submarine mortar is on the quarter deck.

Submarines

H.M.S. "Explorer" (see page 30), the first submarine of entirely post-war construction to be completed for the Royal Navy, and the first of two experimental high-speed submarines, was provisionally accepted into service on May 8, 1956, from Vickers-Armstrongs, Ltd., Barrow-in-Furness, which is completing her only sister ship, the "Excalibur," which took the water on February 25, 1955. With a displacement of 780 tons standard and about 1000 tons submerged, this vessel has a length of 178ft 1in between perpendiculars and 225½ft overall, a beam of 15ft 8in and a draught of about 11ft. Main machinery consists of a modern version of the diesel-electric propulsion system which can be augmented by turbine machinery in which the energy is supplied by burning diesel fuel in decomposed hydrogen peroxide. The two vessels of the "Ex" class will make experiments and will serve to provide experience in the operation of this propulsive combination and act as fast underwater targets to train surface forces in the tactics which would be required to destroy submarines with high underwater speeds. The special turbine machinery was developed under the direction of the Admiralty by a special design team at Vickers-Armstrongs. Both submarines are fitted with the latest submarine escape arrangements. They will not be armed, and their peacetime complement numbers only four officers and nineteen ratings.

H.M.S. "Porpoise," the first post-war operational type submarine, and the first of the new "Porpoise" class of eight units, was launched on April 25, 1956, at the Barrow-in-Furness shipyard of Vickers-Armstrongs (Shipbuilders), Ltd. Seven others are under construction at various yards. This class of submarine has a displacement of approximately 1500 tons standard and 2000 tons full load, with an overall length of 295½ft, a beam of 26½ft, and a draught of about 15ft. The main machinery is orthodox, but the electric propulsion system by the English Electric Company, Ltd., is of a much more advanced design than hitherto used.

(*To be continued*)

Grinding Wheel Dressers.—A new design of grinding wheel dresser, introduced by Danite Hard Metals, Ltd., Carr Hill, Doncaster, consists of a composition of numerous particles of diamonds and boron carbide bonded in a hard carbide matrix. This matrix is an abrasive, which is itself only a little below the hardness of the natural diamond and as it interlocks with even the smallest diamond particles, all the diamonds are completely consumed.

Industrial and Labour Notes

Overseas Trade

The Board of Trade's returns for November show that exports of United Kingdom goods and manufactures were maintained at the high level reached in October. The value of exports in November was £291,900,000, and as there were only twenty-six working days, compared with twenty-eight in October, the daily rate of export was actually higher in November than in the preceding month. Re-exports in November were valued at £14,800,000.

The value of imports was £319,600,000, which was almost £35,000,000 below the October figure, and was 2 per cent below the average for the first ten months of last year. It must not be overlooked, however, that imports in the latter half of November were reduced owing to the diversion of shipping round the Cape. Normally, the Board of Trade says, about two-ninths of the United Kingdom's imports (by value) come through the Suez Canal or the Iraq oil pipeline ; this includes the bulk of our import trade with the Persian Gulf and Red Sea areas, British East Africa, the Indian sub-continent, South-East Asia, the Far East, and Australia. Total imports from these areas in November were 24 per cent below the monthly average for January to October.

In surveying the commodity pattern of trade in November, the Board of Trade says that the trends were very similar to those noticeable in October. Exports of engineering products amounted to £112,000,000, which was a little higher than the October total, whilst exports of metals, valued at £42,000,000, were slightly lower. Among the engineering exports, there were increases in November in ships and boats, machinery (both electric and other), and in scientific instruments. When the two months, October and November, are considered together, it is shown that exports of engineering products were 6 per cent above the high rate maintained in the first nine months of last year. Exports of ships and boats were one-third more, and railway vehicles one-quarter more, while exports of electrical machinery and apparatus increased by 10 per cent, and of machinery other than electric by 5 per cent. Exports of road vehicles in October and November equalled the monthly rate for the first three-quarters of the year, though there was a small decline in shipments of commercial vehicles and chassis. Exports of aircraft, however, were lower in October and November, after being very high in the earlier part of last year.

The Size of Manufacturing Establishments

In accordance with the provisions of the Statistics of Trade Act, 1947, the Ministry of Labour collects, periodically, information about the size of manufacturing establishments in Great Britain. The latest returns of this kind were made a year ago, and the Ministry has now published an analysis of them. At the end of December, 1955, the total number of manufacturing establishments in this country with more than ten employees was 56,313. The number of establishments with less than eleven employees is not definitely known, but is thought to be in the region of 150,000.

The Ministry's survey indicates that in the 56,313 manufacturing establishments with more than ten employees, there were 15,509 where the number employed was between eleven and twenty-four ; 10,961 establishments employing between fifty and 100 people ; 723 where there were between 1000 and 2000 employees ; 328 with between 2000 and 5000 employees ; and seventy-nine establishments where the number of employees in each exceeded 5000. Between the years 1952 and 1955, the Ministry's report continues, there was a slight reduction in the number of establishments with more than ten employees. On the other hand, the number of establishments employing 1000 people or more increased from 980 in 1952 to 1130 in 1955, and the number of those with from 500 to 1000 employees increased from 1471 to 1666.

When the figures are arranged in the respective industrial groups it is shown that the total number of manufacturing establishments coming within the " engineering, shipbuilding and electrical goods group " is 8886. This total is made up of 2210 establishments employing from 11 to 24 people ; 3772 with from 25 to 99 employees ; 2089 with 100 to 500 employees ; 436 with from 500 to 1000 employees ; 248 employing from 1000 to 2000 ; and 131 establishments with 2000 or more employees.

Anglo-Polish Trade Agreement

The Board of Trade says that negotiations between representatives of the United Kingdom and Polish Governments resulted in the signing of a " trade arrangement," in Warsaw, on December 31. This arrangement provides a basis for trade between the two countries until the end of 1959. Import quotas will be negotiated annually.

There is provision for purchases by Poland during the current year of United Kingdom goods valued at about £15,750,000. They will include machinery, textiles, motor cars, radio and television equipment, chemicals, dyestuffs, and substantial quantities of mining equipment and semi-manufactured goods. The Board of Trade points out that here there are " new opportunities for a number of United Kingdom exports." There is also provision in the arrangement for the issue, during this year, of import licences up to a total of about £6,500,000 for Polish goods, including various foodstuffs, furniture and some machine tools. In the arrangement which has been made the two Governments have undertaken not to discriminate against each other's shipping.

Problems for the Steel Industry

Among the annual company reports issued this week is that of Dorman Long and Company, Ltd. It is accompanied by a statement from the chairman, Sir Ellis Hunter, which reviews the year's activities. In this statement, Sir Ellis says that the " labour deficit " which faces the industries in the Tees-side area is substantial enough to threaten their planned future expansion, and it is therefore a matter of real urgency that additional craft labour should be attracted to the area. The only effective means of doing this, Sir Ellis urges, would be the provision by local authorities of houses for essential key workers, on engagement.

The statement goes on to say that the maintenance of a heavy demand for steel and the steadily improved performance of the industry in recent years should not be allowed to create the belief that it is only necessary to raise the target and automatically production will also rise. The labour shortage, Sir Ellis comments, is not likely to be the only limiting factor, for, in his view, there is also the possibility of a shortage of raw materials and of transport. The United Kingdom is not the only country importing iron ores ; there are other industrial nations, Sir Ellis points out, which have large and growing needs. Although steps are being taken to develop new sources of supply, the ore will have to be transported to the United Kingdom by sea. Here again, Sir Ellis says, future shipping needs have been anticipated to some extent, but there is no certainty that cargo carrying capacity will be readily available for any rapid increase in imports.

Sir Ellis then remarks in his statement that any increase in the production of home ores will involve mining, and the National Coal Board's experience in attracting labour to the coal mines suggests that the manning of iron ore mines will also be difficult. The steel industry also uses water in very large quantities, and without adequate supplies projects for further expansion of steel-making will be checked in any areas affected in this way. Another factor which Sir Ellis mentions is that any further big advance in steel production will involve a corresponding increase in inland transport facilities. It is obvious, the statement adds, that the railways will need to take this fully into account in the large capital programme they now envisage.

For supplies from overseas, including iron ore and scrap, Sir Ellis says, we are in competition with the steel industries of other countries, but in manpower, inland transport facilities and water supplies, the British steel industry is in competition with other developing industries at home. A realistic assessment of these factors, the statement emphasises, is essential when considering long-term prospects for expanding steel production. The difficulties, Sir Ellis believes, are not insuperable, but, he says, they are very real and should check facile expectations of large steel output increases year by year comparable with those that have been achieved over the past decade.

Restrictive Trade Practices Act, 1956

The Federation of British Industries has published a revised edition of the booklet entitled *Restrictive Trade Practices Act*, 1956 : *a Guide for the Industrialist*. This booklet incorporates the regulations made by the Registrar of Restrictive Trading Agreements, the Registrar's " guide to registration," and the Board of Trade's leaflet on export agreements. It therefore provides a straightforward account of the Act itself and of the various orders, regulations and instructions made under it.

In a foreword, the Federation of British Industries says it must be recognised that the Restrictive Trade Practices Act represents a new and radical departure for this country in that for the first time Parliament has expressed, through this measure, " a general disapproval of restrictive practices on the management side of industry and commerce." Leaving on one side the provisions affecting the enforcement of resale prices, the effect of the Act in practice will be that restrictive agreements affecting home trade will first be made public, and then be stopped one by one, unless in each instance those who operate them can establish a case for exceptional treatment. Parliament, the F.B.I. comments, has decreed and narrowly defined the circumstances in which exceptions may be made. The task of the new Restrictive Practices Court, important though it is, is thus the comparatively limited one of deciding whether a particular agreement does or does not satisfy the tests which must be satisfied if it is to be allowed to continue.

Whether this policy, the F.B.I. adds, will in the long run prove to offer a constructive contribution to industrial and commercial efficiency, and to the economic wellbeing of the country, is a question that only experience can answer. There can be little doubt, however, that it will have a considerable effect on methods of trading.

Changes in Wage Rates

With the changes in wage rates in the United Kingdom which became effective in November, the Ministry of Labour says that in the eleven month period, January to November, 1956, there were 12,415,000 workpeople who received increases aggregating £6,492,400 a week. In the comparable period of 1955, there was a net increase of £4,898,000 in the weekly full-time rates of wages of 11,547,000 workpeople. The index of rates of wages (June 30, 1947=100) stood at 165 for all workers at the end of November last, compared with 154 at the end of December, 1955.

The changes in wage rates notified during November resulted in an aggregate increase of about £154,000 in the weekly full-time wages of 586,000 workpeople. Among those who received wage increases were non-skilled workers in Government industrial establishments, and operating and maintenance staff employed by company-owned motor bus undertakings and by municipal tramway, trolleybus and bus undertakings. The Ministry of Labour says that of the total increase in November, about £81,000 resulted from arrangements made by joint industrial councils or similar bodies ; about £50,000 was the result of direct negotiations between employers and workpeople ; about £18,000 resulted from arbitration awards, and approximately £5000 was the result of the operation of sliding scale arrangements based on the index of retail prices.

Continental Engineering in 1956

No. I

An event of major importance to engineers was the Fifth World Power Conference, which was held in Vienna during the period June 17–23.* These meetings—the previous conference took place in London in 1950—are of ever-increasing interest in view of the global demand for more power, for industry, transport and domestic purposes. As an indication of the main trends of thought on this problem of power generation, among engineers, the 275 papers presented for discussion were as follows :—

Section	No. of papers
A.—Reviews and statistics, 1950–1954	42
B.—Methods of compilation, use of statistics	16
C.—Preparation and conversion of solid fuels	12
D.—Liquefaction of solid fuels, preparation and treatment of liquid fuels	9
E.—Gasification of fuels, preparation and treatment of gaseous fuels	24
F.—Economics and technology of long-distance gas supplies	10
G_1.—Planning of thermal plants	28
G_2.—Construction and operation of steam boilers	23
G_3.—Mechanical equipment of thermal power plants	11
H_1.—Planning of hydro-electric plants	45
H_2.—Construction and problems of mechanical equipment of hydro-electric plants	
J_1.—Atomic energy : reactors	19
J_2.—Atomic energy : raw materials, profitability, auxiliary plant	
K.—Other sources of energy, special processes for their utilisation	11
L.—Purification of waste water in the production of energy	3
M.—Purification of waste gas in the production of energy	5
N.—Technical aspects of international co-operation in the production and use of energy	9
O.—Economic aspects of international co-operation in the production and use of energy	8

At the present time the annual increase in electricity generation in Europe amounts to about 8 per cent, requiring about 7 per cent of the total investments. (It may be noted that for the U.S.S.R. an increase in power generation of 13 per cent per annum is quoted.)

Although energy production can be and is being expanded—the 1955 Report of the European Coal and Steel Community envisages a coal production of 260–265 million tons in 1958 in the Community countries, an increase of 20,000,000 tons over 1954—the rate of expansion of conventional energy must of necessity decrease sooner rather than later. The upper coal seams are being worked out, requiring more difficult operations to reach the existing reserves ; hydraulic power may be almost fully exploited within the next twenty years. Urgent steps are, therefore, being taken in many countries towards putting into use the new form of power, nuclear energy.

Nuclear Programmes

In Switzerland the formation of the research company, Reaktor A.G., Würenlingen, on March 1, 1955, has been followed by the founding of two industrial undertakings, Atomkraft A.G. and Atomelektra A.G. (October, 1956). Research and study groups are at work in many other countries—the Netherlands, Norway and Western Germany must be mentioned. Detailed plans have been announced in Sweden, 95 per cent of whose annual electricity production of 25,000 million kWh is at present hydro-electric. It is, however, expected that all exploitable hydro-electric resources, amounting to 80,000 million kWh per annum, will be in use by 1980. Meanwhile, the Swedish State Power Board, which accounts for about 40 per cent of the total production in the country, has announced its nuclear programme which will initially consist of a 75MW heating plant "ADAM," to be completed in 1960, to be followed in 1963 by "EVA," giving an electrical output of 100MW. "ADAM" will work with natural uranium and a heavy water moderator.

French Atomic Energy

It is France which is the leading Continental country in the field of atomic power. The Gaillard five-year plan adopted in 1952 provided for the construction of two (later, three) uranium-graphite piles serving chiefly for the production of plutonium. The first of these, the G.1. reactor at Marcoule, came into operation in January 1956, and will be described later in this article. An additional three-year programme, involving an expenditure of 100,710 million francs, was introduced by Monsieur Palewski in 1955. It sets out to develop the production of uranium ore and other basic raw materials, extend industrial facilities for uranium metal and such materials as heavy water, intensify the construction of graphite piles and chemical treatment plants, undertake further basic studies and extend research facilities, as well as deal with the development of atomic propulsion for ships.

Sources of fissile material are uranothorianite from Madagascar and uranium ores from various deposits in metropolitan France. These are at Vendée, La Crouzille, Lachaux and Gruet. A factory for the treatment of uranium-thorium ores, built and run by Société Potasse et Engrais Chimiques (P.E.C.), has been in operation since 1950 at Le Bouchet, near the Vendée deposits. At Gueugnon (Saône et Loire) another P.E.C. factory, for the production of sodium uranate, came into operation last year. Another factory for uranium concentrates is being built at Ecarpière (Loire Inférieure) by Société Industrielle des Minerais de L'Ouest (S.I.M.O.) and will be ready next year, while a third concentration plant, at Bessines (Haute Vienne), will go into service in 1958. The last two plants will operate a new process based on ion exchange. Concentrates from these factories go for further treatment to the Le Bouchet centre.

The Commissariat à l'Energie Atomique (C.E.A.) maintains establishments at Châtillon, Saclay, Le Bouchet, Grenoble and Marcoule. Heavy water research reactors EL1 and EL2 are in operation at the first of these centres, while a similar reactor, EL3, is under construction at Saclay.

The Marcoule Centre

Construction of the atomic energy establishment at Marcoule (Gard), 25km northwest of Avignon, was begun in 1954. The site was chosen because of its distance from centres of population and the plentiful supply of cooling water. The absence of airfields in the vicinity obviates any danger to aircraft from the presence of a very tall chimney, and no serious industrial or agricultural losses were involved. The primary purpose of the installation will be the production of plutonium. A plant for the machining of the graphite elements for the piles was the first unit to be completed and came into use at the end of 1954. There are to be three graphite-moderated reactors, G.1, G.2 and G.3, of which G.1 was completed last year after eighteen months' work (see Plate 14). Some of the 40MW of heat developed by this pile, which is air cooled, is converted into electricity and used for supplying the fans. The reactor contains 100 tons of natural uranium and 1000 tons of graphite. About 30,000 tons of concrete were poured in the construction of the pile and 2000 tons of steel were required for the foundations, which rest on a subsoil of gravel overlying clay. The protective walls contain some 50,000 tons of concrete. G.1 will produce about 15 kg of plutonium annually, and an extraction plant for its separation is nearing completion on the site. The second reactor G.2, will also be gas cooled, but in this case carbon dioxide under pressure is to be employed. No details regarding G.3 are available as yet. Altogether, Marcoule will produce about 100 kg of plutonium per year. The G.1 pile was constructed under the direction of C.E.A. by a group of four French companies (Rateau, Alsthom, Société Alsacienne de Constructions Mécaniques, Société des Forges et Ateliers du Creusot), while the power production plant was jointly undertaken by C.E.A. and Electricité de France.

Some Important Hydro-Electric Schemes

In our issue of July 20 we described the work which is at present being carried out on the Danube run-of-river plant at Ybbs-Persenbeug in Austria. This scheme, which is the second of its kind after Jochenstein, will generate 1252 million kWh annually, 56·8 per cent during the summer, from an installed capacity of 192MW. It is scheduled for completion in 1959.

In an illustration overleaf we show one of the Kaplan runners for the scheme during works assembly. The runner has a diameter of 7·4m, and the design flow is 350 cumecs. Gross heads will vary between 6m and 14m, and the turbine runaway speed is 178 r.p.m. There will be six sets of 32MW each, and current will be generated at 68·2 r.p.m., 50 c/s, 10·3kV, stepped up for transmission to 220kV.

The barrage across the river will have five openings, each 30m wide, with piers of 7·5m width, and lowering crest gates 13·5m high. Equipment will include two portal cranes serving both the barrage and power plant, and having a capacity of 130 tons. As at Jochenstein, ample provision is being made for river traffic. There will be two locks with a useful length of 230m and a useful width of 24m, which can be filled in thirteen minutes with 60,000 to 80,000 cubic metres of water. These locks will be on the left bank. There will be two power stations, each housing three sets, on either side of the barrage. During catastrophic floods, when the river may carry up to some 6000 cumecs, the locks can be used to pass about a quarter of the total floodwater. The scheme forms one of fourteen Danube stations between Jochenstein and Hainburg, which, with a total installed capacity of 1940MW and a total head of nearly 160m, will generate 12,651 million kWh per mean year.

A second Austrian power scheme, which was substantially completed this year, is the Glockner-Kaprun scheme in the Hohe Tauern, part of the main Alpine range. It has a gross annual output of 815 million kWh, of which 200 million kWh is absorbed by the Limberg and Möll pumping stations. Of the net output of 615 million kWh, 469 million kWh are generated in the winter. The installed generating capacity amounts to 312·5MW and comprises two 45MW and

* THE ENGINEER, June 22, pages 697 and 705 ; June 29, page 749 ; July 6, pages 1 and 13.

two 55MW horizontal Pelton sets at Kaprun, each powered by two turbines and operating with a gross head of 891m ; also, two 0·27MW auxiliary sets at the same station, driven by horizontal shaft Francis turbines with a gross head of 65m ; two 56MW horizontal shaft pumping sets at Limberg, each with a Francis turbine, generator/motor, and centrifugal pump, working with a gross head of 363m, and two 6·7MW horizontal shaft centrifugal pumps, gross head 80m, at the Möll pumping station.

The Glockner-Kaprun scheme utilises three reservoirs, the Margaritze, south of the main watershed at 2000m above sea level, and holding 4,000,000 cubic metres, and to the north, the Mooserboden (at 2035m, with 84,000,000 cubic metres) and the Wasserfallboden (at 1672m, holding 84,500,000 cubic metres). If side stream intakes are included, the total catchment area at Kaprun is 124·1 square kilometres for the main, and 27·9 square kilometres for the auxiliary sets.

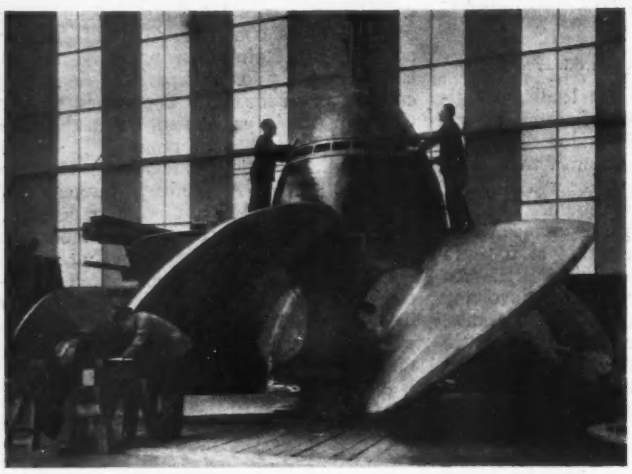
Dams of this scheme include the Limberg arch gravity dam of the Wasserfallboden reservoir, which has a maximum height of 120m, a crest length of 357m, and a volume of concrete of 446,000 cubic metres. On the Mooserboden reservoir are the Mooser and Drossen dams, the first a gravity dam, 107m high and 470m long, with a volume of 670,000 cubic metres, the second an arch dam, 112m high and 357m long, with a concrete volume of 350,000 cubic metres. Finally, there are the Margaritze gravity dam (37m high by 175m long, 33,000 cubic metres), and the Möll arch dam (93m high by 164m long, 35,000 cubic metres). There is a total of nearly 24km of main tunnels varying in diameter from 2·5m to 3·4m, and four 1·15m to 1·25m diameter steel penstocks at Kaprun, each 1·2km long.

The Kapruner Ache River flows into the Salzach where a 120MW run-of-river plant is under construction at Schwarzach, utilising a flow of 100 cumecs with a 149m head ; this will generate 395 million kWh per annum, 41 per cent of it in the winter. A second, 85MW stage, and three subsequent stages will complete the exploitation as far as Salzburg.

Reference should also be made to the Maggia and Alto Chiese schemes, situated, respectively, in Switzerland, north-west of Lake Maggiore, and in the Adamello range of the Italian Alps. Alto Chiese comprises four reservoirs totalling over 72,000,000 cubic metres, and its three power stations, at Boazzo, Cimego and Darzo, produce 621·6 million kWh annually by means of an installed capacity of 339·4MW.

The Maggia scheme, the first stage of which is now virtually complete, has three power stations : Peccia (47MW), Cavergno (55MW) and Verbano (100MW), producing together 883 million kWh per year, of which 375 million kWh are produced in the winter. About 88km of tunnel had to be built, involving 1,100,000 cubic metres of rock. The main dam, at Sambuco, required an excavation of 260,000 cubic metres, and the placing of 775,000 cubic metres of concrete. It is a gravity-arch dam 130m high and 340m long at the crest. The reservoir holds 63,000,000 cubic metres.

Work is proceeding at Lasele power station, Sweden, which is to be completed this year. This is the fourth station of the Ångerman scheme, the others being Kilforsen, Forsmo and Nämforsen. Lasele will produce 610 million kWh in the average year, by means of an installed capacity of 124MW. The underground station will house two Kaplan turbine sets of 87,200 h.p. each, which will operate on a net head of 52m, the highest in Sweden. Above may be seen one of the eight-bladed Kaplan runners which are being built by Nydquist and Holm A.B. and will have a runaway speed of only 300 r.p.m. owing to a special limitation device. The 70MVA, 13·5kV A.S.E.A. generators are driven at a normal speed of 150 r.p.m. The dam is a rockfill structure 25m high, measuring 290m by 6m at the crest, and containing about 110,000 cubic metres of rock and a core of 60,000 cubic metres of impervious earthfill. The catchment area above Lasele is 12,525 square kilometres, and an initial storage of 815 million cubic metres will be available. By regulating four lakes at the Ångerman headwaters, this will be increased to 2200 million cubic metres. Normal flow at the power station is 178 cumecs, varying between 113 cumecs in a dry winter and 1450 cumecs during exceptional floods.



Runner for Ybbs-Persenbeug during workshop assembly (J. M. Voith G.m.b.H.)

One of two Kaplan runners for Lasele power station. Net head 52m, output 87,200 h.p. (Nohab)

Power Transmission

On January 1, 1956, the submarine cable between the Swedish island of Gotland and the mainland was put into commercial use, one year in advance of schedule. The cable is designed to transmit a direct current load of 20MW at 100kV. The biggest problem in connection with this scheme arose from the design of the ionic valves used for rectifying the a.c. supply and inverting the d.c. after transmission. The valves are arranged so that the unavoidable "arcing back" does not affect the operation. During trials in 1955, arcing back occurred twenty-nine times on the rectifiers and sixteen times on the inverters, as well as during special tests. The first valve set was ready by March, 1954, the second in July of the same year. It was not until December, however, that a fairly high peak load (15·4MW) was attained. Damage to the cable from anchors and trawls has occurred, but it is expected that the cable will soon embed itself sufficiently to be protected. The transmission was built by A.S.E.A. for the Swedish State Power Board.

The first Swedish 380kV lines were commissioned in 1952, and by 1958 will total some 1900 miles. A stepping-up of the voltage of existing lines to 450kV or even 500kV is under consideration, and studies are in hand for a 650kV transmission with series capacitor compensation, which would be able to transmit 2000MW. Other design studies concern a d.c. system of ±400kV which would also be capable of transmitting this power.

Last year we described the transmission across the Straits of Messina, with a main span of 3650m. An even longer span is the one over the Sognefjord, hear Refsdal, Norway. It is formed by three-phase conductors and one spare conductor, the horizontal distances between the end points varying between 4830m and 4890m. The 9m high supporting towers are of reinforced concrete and are spaced at distances of 50m, on the Fatlaberg in the north at 780m above sea level, and on the Rabnaberg in the south at 480m above sea level. The fjord at this point has a width of 3700m, and the lowest point of the lines is 68m above the water. Each conductor is made of galvanised steel wire, with a core wire 3·6mm in diameter and three outer layers of 3·2mm diameter wires. The cables were supplied in lengths of 5100m, each length weighing 14 tons. The wire tension of 15 tons is carried at each end by six insulators arranged in two groups of three, each insulator being made up of ten elements and having an ultimate strength of 11·5 tons. Special vibration dampers are provided. The transmission is dimensioned for 150kV, though operated at 60kV for the time being.

(*To be continued*)

American Water Power Schemes in 1956

BY OUR AMERICAN EDITOR

No. I

PROGRESS of civil engineering construction in the United States during the past year was again influenced much by political developments in the field of power generation and, as the second four-year term of the Republican Administration of President Eisenhower commences, it seems appropriate to review the recent activities of the U.S. Bureau of Reclamation, whose policy has been guided largely by the so-called "partnership" programme between the Federal Government and local interests. Altogether, there have been ten new projects or divisions of projects authorised for construction during the last year. One of the new schemes authorised and placed under construction in 1956 is the Colorado River Storage project. The President broke ground for the Glen Canyon and Flaming Gorge dams only a few months ago. Early construction on the Ventura project in California resulted from an extraordinarily high degree of co-operation on the part of the water users. They executed a repayment contract within a week after the President signed the Ventúra authorisation bill into law, thus providing an added incentive for the Congress to appropriate construction funds immediately.

During the past year, the important investigation and planning work which must precede any authorisation or construction was moving ahead faster than ever before. In the drought-stricken South-west, the Bureau is working on the large Texas Gulf Basin survey with a target date of 1960. It is nearing completion of promising studies on the Garrison diversion project in North Dakota and recently issued a progress report on the Oahe in South Dakota. Construction is under way on the Glen Canyon and Flaming Gorge dams, and advance planning is proceeding on the authorised participating irrigation units. The Bureau is proceeding with an investigation of the additional units proposed for the Upper Colorado River Storage project. In California, it has 1,000,000 dollars this year to help solve the critical water shortage that State is facing. In the Columbia River basin 1,430,000 dollars is available for a further investigation of water conservation and use.

During the past session of the Congress the Colorado River Storage project and other authorising legislation passed by a considerable majority. In the Crooked River and Colorado River Storage project legislation, the Congress reaffirmed again the principle of using power revenue to retire irrigation costs beyond the ability of the water users to pay in limited time. The pooling of power revenues in a basin account for project financing purposes was clearly established in the Colorado River Storage project and should have far-reaching effects on the course of future reclamation work.

During its last session, the Congress passed and the President signed, the so-called "Small Projects Act." This will permit local irrigation districts and others to undertake their own irrigation projects with the aid of Federal loans and grants. Firmly supported by the Department of the Interior and the Administration, it is another important development in the water resources field and will undoubtedly prove to be a very strong incentive to irrigation development all over the country. This Small Projects Act further develops the "partnership" concept of the Eisenhower administration. In the field of non-Federal enterprise, local power co-operatives, municipalities and private companies also are moving ahead on their own in the development of some river sites. However, they are licensed only after their plans are reviewed by the Federal Power Commission and commented upon by the Department of the Interior and other affected agencies. This procedure is calculated to make certain that those projects also fit into the multi-purpose needs of the river basin. Under the "partnership" plan, non-Federal utility companies provide the necessary capital to construct the hydro-electric facilities in multi-purpose dams. In return, they obtain the power produced during the amortisation period. Thereafter, the Federal Government may dispose of the power in any way the law provides. The revenue from its sale will be available for other purposes, just as it will be on dams totally financed by the Federal Government.

The importance of reclamation work is underlined by the fact that the United States has lost nearly 5 per cent of its cropland to suburbs, airports, highways and industrial expansion in the last fifteen years. The net effect has been to take nearly a quarter-million farms and ranches out of production. Generally these farms are in the valleys with the best soil and water supply. The largest losses of farmland have been in California and from Texas east. There is little likelihood that these losses will be stopped or even slowed down much in the near future.

In the past the Bureau has been subject to severe criticism from organisations concerned with preserving the outdoor recreation and fish and wild life resources with which the West is so plentifully endowed. It has gone to great lengths to consult and co-operate with these organisations and with the local, State and Federal agencies concerned. Thus, the Bureau maintains that it has enhanced rather than damaged these important assets to the West's economy and pleasure and has added materially to the national recreation, fish and wild life and other resources. During this past year the Bureau completed an inventory of reclamation reservoirs which are contributing to the enjoyment of fishermen and recreation seekers. There are 140 reservoirs or other facilities being utilised for some recreation purpose and they are attracting some 10,000,000 users annually. The directory shows that the Lake Mead recreation area created by the Hoover and Davis dams attracted 2,600,000 visitors last year, and that there were fifteen others which drew more than 100,000 people each, running up as high as 900,000 at Jackson Lake and 750,000 at the Buffalo Bill reservoir on the Shoshone River.

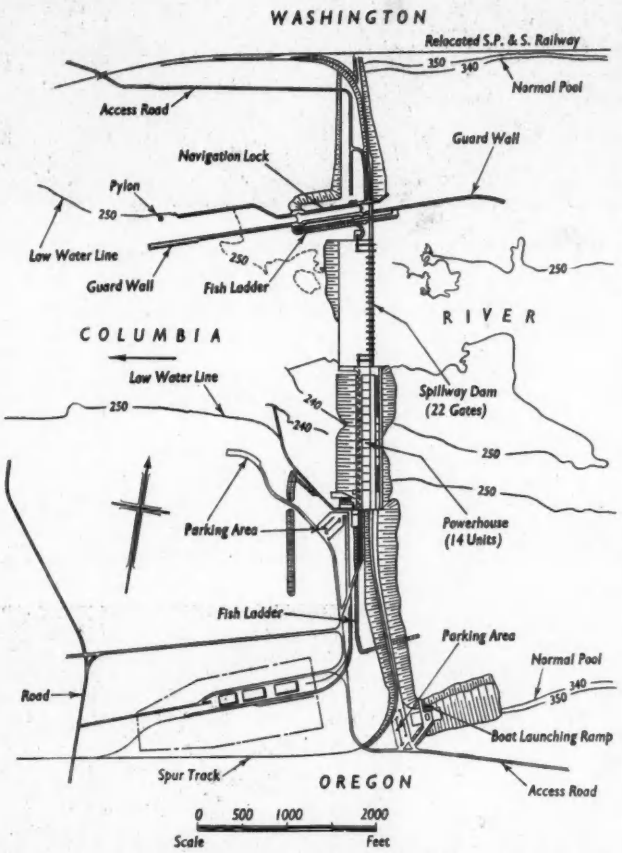


Fig. 1—General arrangement of the McNary dam of the U.S. Army Corps of Engineers on the Columbia River

The "basin-wide" concept of water resources development received a powerful impetus with the recent passage of the Colorado River Storage project. It is worth noting also that this concept was recommended by the Hoover Commission in its report a year ago and has subsequently been accepted by the Administration. The Hoover Commission recommended "that water resources development should be generally undertaken by catchment areas—locally and regionally." The White House, in a progress report on the Hoover Commission recommendations, issued last October, noted that this recommendation had been accepted and that implementation was in progress. The Hungry Horse reservoir is an excellent example of the advantages to be gained by such a development. The water stored there increases the firm power output of the Columbia River system by 810MW. The Hungry Horse plant alone has 285MW of installed capacity and only a relatively small part of this capacity would be firm were it not for integration with the entire river

Fig. 2—Spillway and power station of the McNary dam on the Columbia River

system. The upstream storage obviously benefits not only Federal hydro-electric plants, but others as well. The firm capacity of the Kerr dam of the Montana Power Company at the Flathead Lake is more than doubled by the storage capacity at the Hungry Horse reservoir. It is worth considering, too, just what a " basin account " created by the pooling of power revenues in the Pacific Northwest would mean to the development of the land resources there. Much of the irrigation work there is being aided by the power revenue from specific dams, the most recent being the authorisation for the Crooked River project to be aided by revenue from the Dalles dam. There are vast quantities of land in the Pacific Northwest susceptible to irrigation, but it will be a costly process to bring water to them. There is not yet the pressing need that there will be in future decades. The " basin account " principle, which is contained in the Colorado River Storage project authorisation, would be a big step in the eventual development of these lands.

McNary Dam

The construction of the McNary Dam, one of the major multiple-purpose reclamation schemes of the U.S. Army Corps of Engineers, was completed in 1956. The dam and lock of this scheme have been built on the Columbia River between the States of Oregon and Washington. The power station comprises fourteen 70MW turbo-generators, giving the scheme a 980MW nominal capacity. The McNary dam and lock is part of a comprehensive programme for the development of the Columbia River and its tributaries. The dam structures, containing 1,850,000 cubic yards of concrete and 21,000,000 cubic yards of earthfill, extend across the valley a distance of about 7600ft. As shown in Fig. 1, the earthfill extends from the bank on the Washington shore, a distance of 1560ft, to join the concrete structure. The navigation lock, on the Washington shore has clear dimensions of 86ft by 675ft and a minimum depth of 12ft over the mitre sills and covers the entire head of the scheme in a single lift. Guard walls, which are approximately 1400ft long, extending both upstream and downstream from the lock chamber, protect the river traffic from the spillway. An unconventional aspect of the lock design is the use of four sector gates in the filling and emptying culverts, with the concave faces of the gates on the pressure side. Model studies showed that far less turbulence was experienced during raising and lowering of the gates when they were placed in this manner. To provide access across the lock a double-leaf bascule bridge has been constructed. Immediately south of, and adjacent to, the lock is the non-overflow section of the dam through which the Washington shore fish ladder passes.

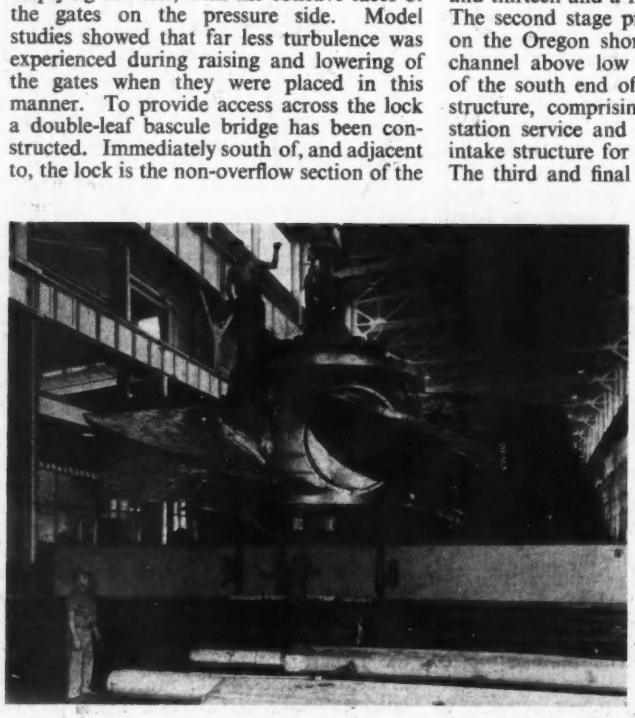


Fig. 3—280in diameter six-blade Kaplan turbine rotor prior to despatch to the McNary power station

The spillway of the dam, which is shown in Fig. 2, extends to the south and consists of a concrete ogee section, controlled by twenty-two two-section, vertical-lift gates, 50ft wide and approximately 53ft high. The gates are operated by two 200-ton gantry cranes. A concrete stilling basin with baffles is provided downstream from the spillway. The lower sections of the gates, which are 24ft 6in high, normally remain seated on the crest of the ogee section, and the upper sections are then raised and lowered to regulate the pool level. With all gates removed the spillway is designed to pass 2,200,000 cusecs, or practically twice the maximum flood on record. Another non-overflow section of the dam, which is situated between the spillway and the power station, has an entrance to the Oregon shore fish ladder. This entrance is controlled by closed flume along the downstream side of the power station. In addition, there is a collecting and passage channel extending the full length of the power station and having a total of eighty-seven entrance openings, forty-four of them equipped with automatically operated telescopic gates. There is also an entrance at the south end of the power station.

The power station, which is situated south of the spillway, houses fourteen 70MW generators, driven at 85·7 r.p.m. by Kaplan turbines, two station service generators and an assembly bay. The dam raises the natural water surface 85ft and creates a pool extending 64 miles upstream. At the dam site the Columbia River has a mean annual flow of 190,000 cusecs, varying from an extreme low of 33,000 cusecs to the high record of 1,210,000 cusecs, which occurred in 1894. To provide for the passage of the entire flow of the river and to keep interruptions in river navigation to a minimum, construction was divided into three major stages. The first-stage cofferdam, on the Washington side, above the low-water channels, included the navigation lock, the north non-overflow section, the Washington shore fish ladder, and thirteen and a half bays of the spillway. The second stage provided for a cofferdam on the Oregon shore adjacent to the main channel above low water, for construction of the south end of the power station substructure, comprising two main unit bays, station service and assembly bays, and the intake structure for that part of the station. The third and final stage included the construction of (1) twelve main unit bays of the power station substructure and intake structures for these bays; (2) the entire power station building; (3) the south non-overflow section of the dam; (4) eight and a half bays of the spillway within the main second-stage cofferdam, and raising the ogee section of the partially completed spillway bays; (5) completion of the upstream sill block of the navigation lock; (6) completion of the fish ladder on the Oregon shore; and (7) completion of embankments on both the Washington and Oregon shores. The pool was raised to its minimum operating level in the spring of 1953 on completion of the ogee crest of the spillway and the sill block of the navigation lock.

Fig. 3 shows one of the 280in diameter six-blade Kaplan turbine rotors leaving the works of the S. Morgan Smith Company for the dam site. The design head of these turbines is 80ft, with a range of head from 62ft to 92ft. The firm capability of the plant is attained in cases of river flows up to 800,000 cusecs with the reservoir pool being held to its normal elevation of 340. The

turbines deliver in excess of the required 111,300 h.p. at a net head of 80ft, which is their rated output, and at least 93,000 h.p. at a net head of 63ft. The turbines and generators are both designed to withstand, at working stresses not exceeding two-thirds of the yield point, an overspeed of 190 r.p.m. The maximum "on cam" overspeed is 186 r.p.m., determined from model tests. The highest speed attainable, however, is approximately 217 r.p.m., also determined by model tests, resulting from a critical false blade angle to gate opening relationship which is possible but highly improbable. The working stresses of both turbine and generator at this maximum speed will be approximately 87·5 per cent of the yield point of the materials. The specifications under which the turbines were purchased required a guaranteed efficiency of not less than 86 per cent at rated head and load as determined by model tests. The model tests indicate that turbine efficiencies up to 94 per cent may be expected at best gate operation, with a resultant expected plant efficiency of about 91 per cent.

Palisades Dam

Water storage started in October, 1956, at the Palisades dam on the Upper Snake River in Idaho and, as shown in Fig. 4, the main embankment of this important structure is now almost complete. The Palisades dam scheme embraces the largest earth-fill dam ever constructed by the U.S. Bureau of Reclamation and a 1,400,000 acre-foot reservoir. The dam is situated in Eastern Idaho, 8 miles west of the Wyoming border and approximately 44 miles east of the city of Idaho Falls. The Palisades power station will consist of four generators, each rated at 28·5MW. The estimated annual output will be 134 million kWh of primary hydro-electric energy and 385 million kWh of secondary energy. Initial power is scheduled to be generated early this year. The estimated cost of the Palisades scheme is 76,601,000 dollars, of which 53,355,000 dollars will be repaid to the Federal Treasury by the water users and through the sale of power.

The dam is a rock-faced, earth-fill structure, having a total volume of approximately 13,800,000 cubic yards. The structure is 258ft high, 2200ft long at the crest, 2250ft wide at the base, and 40ft wide at the crest. The elevation of the crest is 5630ft above sea level. The dam is situated on the Snake River, which is second in flow only to the Columbia in the Pacific Northwest of the United States. The origin of the Snake is in the southern part of the Yellowstone National Park, on the west side of the Continental Divide in Wyoming. The left abutment of the dam consists of rock of igneous origin—andesite—which is very hard and stable. The foundation and the right abutment of the dam consist of tilted sedimentary beds, mainly comprising highly compacted clayey silt stones, which will be adequate to support the weight of the dam.

A controlled discharge spillway, consisting of one 28ft inside diameter tunnel, 1850ft long, carries surplus flows of the Snake River past the dam. It extends from the surface of the reservoir through the left abutment to the river below and has a maximum capacity of 48,000 cusecs. Two concrete tunnels, which are lined with steel from the dam axis to the outlet end, constitute the outlet works. They have a capacity of 30,000 cusecs at a reservoir elevation of 549ft and each has an inside diameter of 26ft. One of these tunnels carries water to the penstocks and both served as diversion tunnels during construction. As shown in Fig. 4, the power station has been constructed at the downstream toe of the dam at the left abutment. It is approximately 100ft by 246ft wide and is the first brick power station constructed by the Bureau of Reclamation. The dam is creating a reservoir approximately 20 miles long and 3 miles across at the widest point. It will extend about 5 miles across the Idaho-Wyoming border, have a surface area of 16,100 acres, and a capacity of 1,400,000 acre-feet. The operation of the Palisades reservoir will be co-ordinated with that of the existing American Falls and Jackson Lake reservoirs to ensure that a maximum volume of storage water can be carried over in all three reservoirs from wet cycles to dry cycles.

When construction of the dam began in the summer of 1952, the Snake River was diverted around the work area through a 1450ft long diversion channel cut across the natural bend of the stream. In 1953 it was further diverted through the concrete-lined power and outlet tunnels in the left abutment of the dam. The body of the earth-fill dam is a rolled embankment. The centre and most of the base is an impervious core, blanketed by zones of stable free-draining materials. A layer of rock will be placed on the upstream and downstream faces of the dam to prevent erosion. Two concrete cut-off walls extend along the left abutment and two cut-off trenches underlie the dam. The impervious section of the dam consists of deposits of clay, silt and sand, and a surrounding zone of the same material mixed with some gravel, cobbles and small rock fragments. The material placed in these impervious zones was compacted into successive layers, 6in deep, by 20-ton sheepsfoot rollers, each 5ft in diameter, which made an average of twelve passes over it. The outer slopes and crest of the earth-fill embankment are of free-draining sand, gravel and cobbles compacted into successive layers of 12in depth by crawler tractors. The upstream face of the dam is a blanket of rock riprap and the downstream face a layer of rock cobbles. The material for the earth embankment and the aggregate for concrete were found to be available in a number of borrow areas near the dam site.

(*To be continued*)

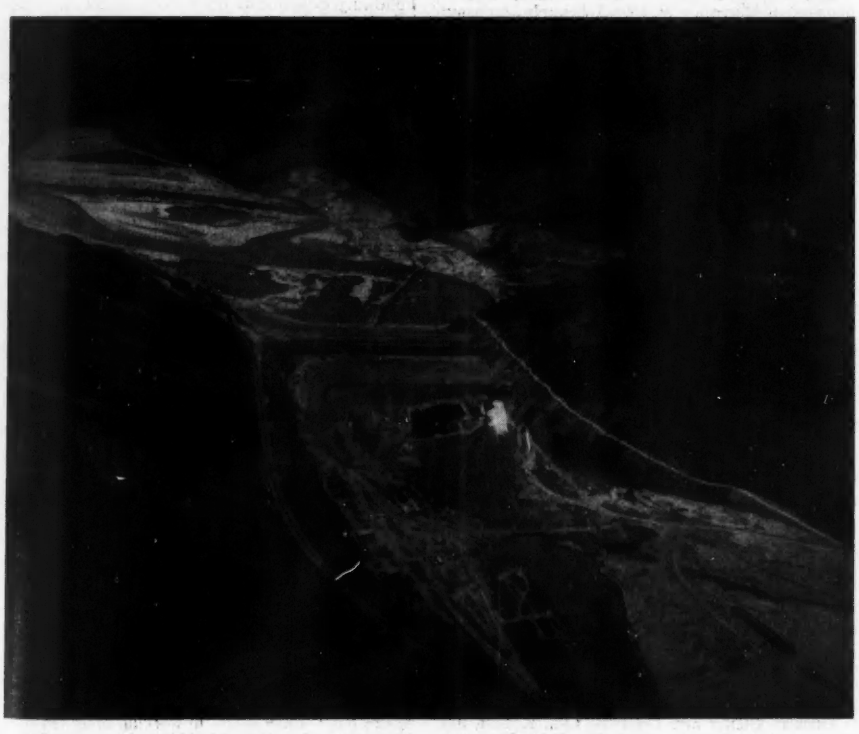


Fig. 4—Aerial view of the Palisades dam of the U.S. Bureau of Reclamation on the Upper Snake River in Idaho

International Congress on Irrigation

Delegates of thirty-four member countries will assemble in San Francisco in the spring for the Third Congress of the International Commission on Irrigation and Drainage. The proposed sessions in the Sheraton-Palace Hotel from April 29 to May 4 will be the first ever held in the United States. The Third Congress follows the previous congresses held in India in 1951 and in Algeria in 1954. The United States National Committee will act as host, and Mr. Walter E. Blomgren, of Denver, Colorado, is the committee's chairman. The programme will cover papers on four topics or "questions"—canal lining, soil-water relationship in irrigation, hydraulic structures on irrigation and drainage systems, and the inter-relation between irrigation and drainage. Each participating country or national committee has been invited also to submit reports on problems in irrigation and drainage development and practice, and associated problems of weed control, and ground water.

Two weeks of study tours will follow the technical meeting, giving visitors the opportunity to see both private and public water developments in the western United States and visit works which manufacture irrigation equipment and machinery. An inspection of irrigation development and research at the University of California's agricultural experiment station at Davis, California, will be available to all who participate in the study tours. Thereafter, two simultaneous tours will take in other work and activities, including structures and lands in the Sacramento River valley, the dams, canals and irrigation systems in the Central Valley, and the Department of Agriculture's salinity laboratory at Riverside. A later study tour is planned to cover the Bureau of Reclamation's Columbia Basin Project. Information about the Third Congress may be obtained from the United States National Committee, International Commission on Irrigation and Drainage, Post Office Box 7826, Denver 15, Colorado.

Personal and Business

Appointments

MR. H. L. A. FOY has been appointed publicity manager of Decca Radar, Ltd.

MR. C. A. WINSTANLEY has been appointed service manager of H. Leverton and Co., Ltd.

MR. FRANK ROWE has been appointed a director of The George Cohen 600 Group, Ltd.

MR. M. LYTH, A.M.I.Mech.E., has been appointed production manager of the Lincoln Electric Company, Ltd.

MR. K. S. SMITH has been appointed northern representative of the Midland Heating and Ventilation Company, Ltd.

MR. EDGAR LEWIS has been appointed a member of the Co-ordinating Advisory Committee on Oil Pollution of the Sea.

OPPERMAN GEARS, Ltd., has announced the appointment of Mr. Alfred Black as sales director. Mr. Cyril Warren has been appointed a director.

MR. D. F. WAGSTAFF has been appointed chief engineer of Plowright Brothers, Ltd. Mr. G. L. Doris has been appointed the technical sales manager.

BROOK MOTORS, Ltd., has announced the appointment of Mr. K. Broom as manager of the Leicester sales office. He succeeds Mr. J. P. Swain, who has retired.

FERRANTI, Ltd., announces the appointment of Mr. C. M. L. Walker as sales consultant in the Midlands. Mr. R. S. Winter has been appointed area manager.

AIR VICE-MARSHAL C. D. C. BOYCE has been appointed assistant controller of aircraft, Ministry of Supply, in succession to Air Vice-Marshal H. D. Macgregor.

MR. FORBES JACKSON has been appointed chairman of the Wiring Regulations Committee, Institution of Electrical Engineers. Mr. S. E. Goodall has been appointed vice-chairman.

WILLIAM SIMONS AND CO., Ltd., states that Mr. J. Kenneth Weir has been appointed chairman and that Mr. J. Russell Lang and Mr. J. W. W. Drysdale have been appointed directors.

GEORGE CLARK AND NORTH-EASTERN MARINE (SUNDERLAND), Ltd., announces that Mr. P. Kendra, works manager of the Southwick Engine Works, has been appointed a director.

RALEIGH INDUSTRIES, Ltd., Nottingham, has announced that Mr. E. E. Baker, Mr. B. L. C. Dodsworth and Mr. D. S. Robinson have been appointed assistant managing directors.

MR. C. E. EVANS has been appointed general manager of British Hydrocarbon Chemicals, Ltd. Mr. D. Blair has been appointed works general manager at Grangemouth.

NEGRETTI AND ZAMBRA, Ltd., has announced the following appointments :—Mr. L. B. Lambert, overseas manager ; Mr. Arthur Muir, home sales manager ; Mr. R. L. Spiller, chief technical correspondent.

THE ROYAL SOCIETY announces the following appointments as vice-presidents for the year ending November 30, 1957 :—Sir David Brunt, Professor G. L. Brown, Sir Claude Gibb, and Sir Bryan Matthews.

MR. DOUGLAS G. OGILVIE has succeeded Mr. John Bulman as managing director of Hawthorn Leslie (Engineers), Ltd., and also as director of Hawthorn Leslie (Shipbuilders), Ltd., and of R. and W. Hawthorn, Leslie and Co., Ltd.

LONDON TRANSPORT states that Mr. J. H. F. Read has been appointed principal executive assistant. He will be responsible to the New Works Engineer for matters concerning the heating and ventilation of London Transport's properties.

THE GLASS MANUFACTURERS' FEDERATION has announced the following elections :—Mr. L. T. Sawney, M.C., president ; Mr. A. W. Clark, chairman of the executive committee ; Mr. I. B. Throndsen, vice-chairman of the executive committee.

FOLLAND AIRCRAFT, Ltd., announces the following appointments : Mr. E. N. Egan, assistant managing director ; Mr. A. E. Lane, secretary ; Mr. P. P. Nelson-Gracie, technical sales manager. Mr. J. A. Grace has resigned his position as commercial director.

MR. T. DAWSON has been appointed group export sales manager of the Chloride Group of Companies, and will, in addition, be responsible for commercial liaison with the group's overseas associate companies. Mr. P. C. Aspinall has been appointed export manager of Chloride Batteries, Ltd.

VICKERS, Ltd., announces the following appointments in the Vickers Group of companies :—Mr. E. E. Kennard, has been appointed to the board of Cooke, Troughton and Simms, Ltd. ; Mr. H. F. Judd has been appointed to the board of Ioco, Ltd. ; Sir Fred G. Thorpe has been appointed to the board of Vickers Australia Pty., Ltd.

STEELS ENGINEERING PRODUCTS, Ltd., announces that its board is now constituted as follows :—Mr. James Steel, chairman ; Mr. A. Hallsworth, managing director ; Mr. A. G. Howe, finance director ; Mr. R. J. Lester, design director ; Mr. R. L. E. Keates, home sales director ; Mr. R. F. Albon, overseas sales director ; Mr. D. Hassall, production director.

THE ROYAL MILITARY COLLEGE OF SCIENCE, Shrivenham, states that Professor Charles Holt Smith has been seconded for three years from December 31 to be Dean of the Institute of Armament Studies, Kirkee, Poona 3, India. Professor Kenneth Hayes has taken over the headship of the department of instrument technology at the Royal Military College of Science.

RICHARDSONS, WESTGARTH AND CO., Ltd., has announced that Sir Summers Hunter has retired from the board of directors. He has been elected honorary president of the North Eastern Marine Engineering Company, Ltd. Mr. Harry Hunter has retired from the parent board, but remains a director of the North Eastern Marine Engineering Company, Ltd., and George Clark and North Eastern Marine (Sunderland), Ltd. Mr. J. E. Smith and Mr. G. L. Hunter have been appointed to the parent board. Mr. A. H. I. Kinsman and Mr. P. Kendra have been appointed directors of George Clark and North Eastern Marine (Sunderland), Ltd. Mr. A. D. McN. Boyd has been appointed land sales director and Mr. E. A. Eborall and Mr. J. E. Lee, regional directors, of Richardsons, Westgarth (Hartlepool), Ltd.

Business Announcements

CROMPTON PARKINSON, Ltd., wishes to explain that the reference in its advertisement on page 134 refers to draft B.S. C.W. (E.L.E.) 6246.

BRISTOL AIRCRAFT, Ltd., has announced the formation of a sales engineering section. Mr. Alec Symon has been appointed manager.

BROOK MOTORS, Ltd., Newcastle, states that its Newcastle sales office has been moved to 6, Archbold Terrace, Newcastle upon Tyne (telephone, Newcastle 81–1003).

BRITISH POLAR ENGINES, Ltd., Glasgow, member of Associated British Engineering, Ltd., has taken over the Controllable Pitch Propeller Company as a subsidiary.

MR. RAYMOND DORRINGTON BANGAY, foreign manager of Marconi's Wireless Telegraph Company, Ltd., is retiring after more than fifty-four years in the service of the firm.

THE UNITED STEEL COMPANIES, Ltd., has formed a new department for operational research and cybernetics. Mr. Stafford Beer has been appointed head of the new department.

LLOYD'S REGISTER OF SHIPPING (LAND DIVISION) is to carry out inspection during construction of the atomic power stations which are to be built for the Central Electricity Authority.

MR. J. ANDERSON has retired from Lloyd's Register of Shipping. Mr. S. Archer has been appointed to succeed Mr. Anderson as principal surveyor on the chief engineer surveyor's staff at headquarters.

ROLLS-ROYCE, Ltd., has announced the formation of a centralised sales organisation to concentrate on the railcar side of its oil engine business. This department will be in the charge of Lieut.-Colonel L. F. R. Fell, M.I.Mech.E.

CHEMICAL CONSTRUCTION (GREAT BRITAIN), Ltd., is the title of a newly-formed company which has absorbed the former engineering division of the American-owned Cyanamid Products, Ltd. Mr. Michael S. Henderson has been appointed managing director.

CHARLES S. W. GRIGG, Ltd., Staines Road, Hounslow, has joined the Triplex Group of Companies as a subsidiary of Weldall and Assembly, Ltd. Mr. E. E. Toon has been appointed chairman of the new company and Mr. Charles S. W. Grigg, managing director.

RICHARDSONS, WESTGARTH AND CO., Ltd., states that it is a member of the newly formed British atomic group. Other members are International Combustion (Holdings), Ltd., and Crompton Parkinson, Ltd. The group will operate through a joint company, Atomic Power Constructions, Ltd.

GILBERT GILKES AND GORDON, Ltd., Kendal, has announced the retirement of Mr. Eric Crewdson, A.M.I.C.E., from the board of directors. He will continue to direct the research and technical development work of the company and to represent the firm on the committee of the British Hydromechanics Research Association and other engineering and research organisations.

RUSTON AND HORNSBY, Ltd., states that it has created a new sales division in its export sales to deal with business from oilfields. Mr. Brian S. Page will head the new department. A new small engine sales department has been formed to deal exclusively with the marketing of engines up to 150 b.h.p. in the United Kingdom and Eire. Mr. John Needham has been appointed as manager, small engine sales.

Contracts

THE ENGLISH ELECTRIC COMPANY, Ltd., is to supply two of the largest three-phase transformers yet built, to the order of the Tennessee Valley Authority, for its new power station at Gallatin, Tennessee. Each transformer is of 345MVA capacity and will transform the generator pressure of 22·5kV up to the transmission voltage of 165kV. The value of the contract is over £300,000 and the transformers will be built in the English Electric works at Stafford.

ALEXANDER STEPHEN AND SONS, Ltd., has received an order from the British India Steam Navigation Company, Ltd., for the re-engining of the "Ormara." This ship, which has a length between perpendiculars of 420ft by 57ft 3in beam, and a tonnage of 5444 gross, was built by William Denny and Brothers, Ltd., and engined by John G. Kincaid and Co., Ltd., in 1947. The existing machinery, 3200 s.h.p., consisting of a triple-expansion engine and a Bauer-Wach turbine, is to be replaced by a free piston gas generator turbine installation of 4000 s.h.p.

Miscellanea

CONSULTING ENGINEERS IN INDUSTRY.—The Association of Consulting Engineers, 36, Victoria Street, London, S.W.1, has published a booklet entitled "The Employment of Consulting Engineers in Industry." The duties and functions of consultants are explained in this publication.

WORLD POWER CONFERENCE SECTIONAL MEETING.—The British National Committee of the World Power Conference has announced that seventeen British papers will be presented at the sectional meeting to be held in Yugoslavia next June. The emphasis of these papers is on the problems of developing fuel and power resources in "underdeveloped" countries, but some of the papers—such as one on underground gasification—refer to purely technical matters.

DISC BRAKES FOR RAILWAY PASSENGER STOCK.—Following experiments on a two-car electric train, it is proposed to fit disc brake equipment on a ten-car train on the Southern Region for full service trials. This brake equipment is being supplied by Girling, Ltd., Tyseley, Birmingham. It is operated by the normal air brake control through the brake cylinder controlling a pair of calliper levers fitted with non-metallic thrust pads. When the brake is applied these pads grip the sides of a disc mounted on the coach axle behind the bogie wheels.

TRACTOR MOUNTED AIR COMPRESSOR.—An air compressor has been developed by B.E.N. Patents, Ltd., High Wycombe, Bucks, for tractor mounting, to provide a mobile self-contained source of air power for tools and other equipment. It incorporates one of the firm's standard two-cylinder, single-stage compressors with a displacement of 35 cubic feet per minute and a working pressure of 100 lb per square inch. A welded support frame of 2in diameter steel tubing forms the air receiver and steel brackets on the side members provide the means of attachment to the tractor. The compressor is belt-driven from the tractor power take-off and it is stated that the equipment is suitable for use on any make of tractor having hydraulic linkage and rear power take-off.

LAST OF THE "BREWERY SHUNTERS."—The recent withdrawal from stock of London Midland Region locomotive No. 47862 marks the last of the former L.N.W.R. 0-4-2 freight tank engines, built to the design of Mr. F. W. Webb. Twenty of these engines were made at Crewe between 1896 and 1901, and they were used mainly for shunting duties, particularly at breweries, a fact which accounted for their frequently being referred to as "Brewery Shunters." No. 47862 was built in November, 1901, and was originally numbered 823 in the L.N.W.R. stock. It had the following leading particulars : cylinders (two), 17in diameter by 24in stroke ; boiler pressure, 150 lb per square inch ; total heating surface, 967 square feet ; total weight in working order, 34 tons 17 cwt ; tractive effort, 16,530 lb at 85 per cent boiler pressure.

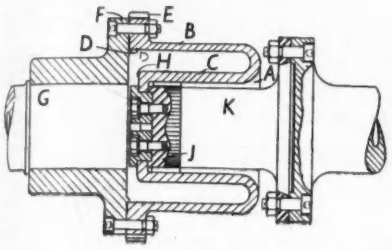
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

POWER TRANSMISSION

763,089. January 22, 1954.—SHAFT COUPLINGS, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2. (*Inventor: Reginald George Whitehouse.*)

Design of the invention has for its object a flexible coupling for shafts which provides transverse flexibility whilst having at least some capacity for angular displacement of the shafts. As will be seen from the drawing, the coupling consists of a substantially



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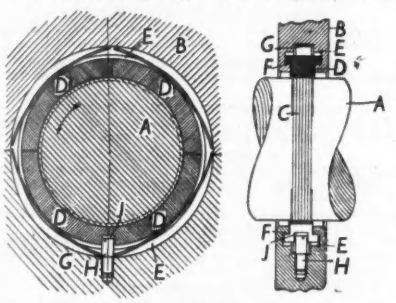
U-shaped flexible tubular member *A* with an outer wall *B* and a re-entrant inner wall *C*. The free end *D* of the outer wall is formed with a circumferential end flange *E* for securing to a flange *F* of a shaft *G* as shown. The inner re-entrant wall *C* is formed with a flange *H* for clamping between the end *J* of a stub *K* or other shaft. It is desirable to ensure that the coupling will have constant torsional strength and with this end in view walls *B* and *C* are given the same polar moment of inertia about the axis of the shafts by making wall *C* of greater thickness than wall *B*.—*December* 5, 1956.

763,373. May 4, 1954.—SEALING GLANDS FOR ROTATING SHAFTS, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2. (*Inventor: Reginald George Whitehouse.*)

The invention relates to improved means for sealing rapidly rotating shafts to prevent leakage of gas between the machine casing and the shaft. The invention is particularly suitable for use in steam turbines, but is equally applicable to electric generators or motors filled with hydrogen or other gases. In the



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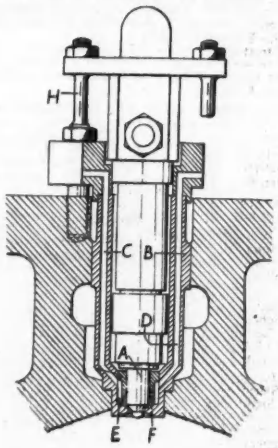
drawing a portion of the casing through which a shaft *A* extends is represented at *B*. The shaft is formed with radial fins *C*. The sealing means is provided by four carbon segments *D* of T-section which are located in grooves *E* in the casing. The sides of these grooves are extended to form a lip or rim *F* on each side which retain the segments and maintain the ring substantially concentric with the shaft. Within the grooves *E* are leaf springs *G* which bear on the segments at their mid portions, and at their ends on the bottoms of the grooves in the region of the joints between the segments *D*. A stop *H*, shown as a screw, projects inwards from the bottom of the groove between the ends of two springs to engage a recess *J* in one or more of the segments to prevent rotation of the segments and springs.—*December* 12, 1956.

INTERNAL COMBUSTION ENGINES

762,792. April 12, 1954.—THE COOLING OF FUEL NOZZLES, Nydqvist and Holm Aktiebolag, Trollhättan, Sweden.

Internal combustion engines having fuel injection nozzles and operated by heavy fuel oils or by diesel fuels with a high carbon residue and a high asphalt content are liable to have carbon deposited on the nozzles, and in order to avoid this drawback the nozzles have to be cooled. The invention provides an arrangement which effectively cools the nozzle by supplying cooling medium to the region of the tip, and is of simple design and easy to handle and maintain. In the drawing the lower end portion *A* or nozzle tip is formed as an atomiser, and is surrounded by a sleeve *B*, of a corrosion-resistant material such as stainless steel. The sleeve has channels *C* and *D* through which cooling water is supplied to an annular



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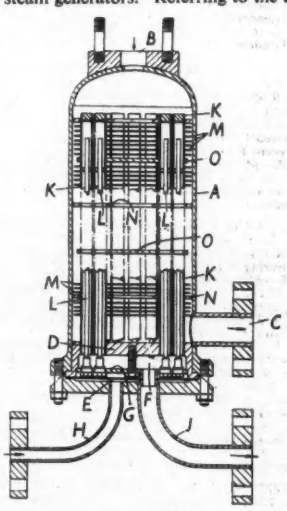
space *E* between the lower end of the sleeve and a heat-conducting bushing *F* which surrounds the injection nozzle tip and which also acts as the seat for the nozzle. This bushing is made of a relatively soft material with good heat conductivity, such as copper or a copper alloy. The bushing *F* surrounds substantially the whole of the nozzle tip, but no part of the nozzle other than its tip. The bushing has at its lower end a flange which seats in the lower end of the sleeve and, as it is pressed against its seat in the sleeve by the injection nozzle, the cooling medium in the space *E* is effectively prevented from entering the cylinder combustion space and the combustion gases are also prevented from penetrating to the space *E*. With this arrangement according to the invention cooling of the injection nozzle tip and the part of the sleeve adjacent the combustion chamber is effectively brought about without substantial cooling of the fuel flowing to the nozzle tip.—*December* 5, 1956.

STEAM GENERATORS

763,136. February 2, 1955.—LIQUID FUEL HEATING APPARATUS, Serck Radiators, Ltd., Warwick Road, Greet, Birmingham, 11. (*Inventor: George Allen Montgomery.*)

The invention has for its object to provide in a simple and convenient form, a steam-heated liquid fuel heating apparatus, the apparatus being required more particularly for preheating the fuel used in oil-fired steam generators. Referring to the drawing,



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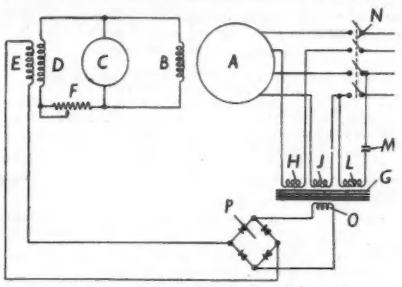
there is provided a vertical cylindrical casing *A* having a central oil inlet *B* at its upper end, and a lateral fuel outlet *C* at its lower end. Alternatively, the relative positions of the fuel inlet and outlet may be reversed. To the lower end of the casing is secured a steam header *D*, which is divided into two compartments *E* and *F* by a horizontal partition *G*. The compartment *E* has a steam inlet *H* and the compartment *F* a steam outlet *J*. Within the casing is an assembly of vertical duplex tubes. Each such tube includes an outer tube *K* which at its upper end is closed, its lower end being secured to the header in communication with the outlet compartment *F*. The inner tube *L* of each of the duplex tubes is concentric with the outer tube and is open at both ends, the lower end being secured to the partition *G* in communication with the inlet compartment *E*. The arrangement is such that steam flows up through each of the inner tubes, and then down through the annular space between the inner and outer tube of each duplex tube. The fuel flows over the outer tubes. To promote efficient transference of heat from the steam-heated tubes to the fuel, the outer tubes are provided with thin metal gill plates *M*. Also within the casing is arranged a number of transverse baffles *N* and *O*, so disposed as to cause the fuel to flow along a zig-zag path between the inlet and outlet. The alternate baffles *N* are of the same diameter and the other baffles *O* are of smaller diameter than the casing. When flowing through the casing the fuel passes alternately through the holes in the one set of baffles and through the annular spaces between the other baffles and the casing.—*December* 5, 1956.

ELECTRICAL ENGINEERING

763,431. April 24, 1951.—ELECTRICAL CONTROL ARRANGEMENT FOR AN A.C. SUPPLY, The Brush Electrical Engineering Company, Ltd., Falcon Works, Loughborough. (*Inventors: David Legg and John De Chair Baker.*)

The invention relates to a new or improved electrical control arrangement suitable for maintaining a substantially constant output voltage from an a.c. generator, and has for one of its objects to provide a control arrangement the electrical characteristics of which may be varied over a considerable range to suit particular requirements. In the drawing the invention is shown as applied to an a.c. generator system in such a way as to control the output voltage of the alternator forming the source of supply, the control arrangement being adapted to maintain the output voltage of the alternator substantially constant despite variations in the load over the normal working range. A polyphase alternator *A* has a field coil *B* excited by a shunt-excited d.c. generator *C* having a field coil *D*. An auxiliary field coil *E* is provided and a variable resistor *F* is in series with the shunt winding *D*, the purpose of this resistance being to vary the value of the excitation current for the coil *B*. The alternator shown is of the three-phase, four-wire kind, but it may equally well be a three-



No. 763,431

phase three-wire machine or one having a greater number of phases. The resultant output of the control arrangement may be obtained from the secondary winding of a transformer having separate primary windings which are energised in constant phase relationship respectively with current and voltage conditions of the current supply from the alternator and to extents proportional respectively to such conditions. The transformer which is indicated at *G* has three primary windings *H*, *J* and *L*, two of which are energised in accordance with the respective current conditions in two lines of the three-phase supply and the third winding is energised in accordance with voltage conditions across two of these lines. The windings *H* and *J* are each connected in series with one of the output terminals of the alternator and therefore are responsive to current variation of its output. If desired, these windings may be inductively coupled to the output lines by means of current transformers. The winding *L* is connected across two of the output lines so as to be responsive to variation of output voltage. A condenser *M* is provided in this circuit as a high impedance to ensure constant current which is unaffected by heavy load conditions. A gang switch *N* is incorporated in the output of the alternator, and one side of the *L* circuit is connected to a line on one side of this switch, the other side of such circuit being connected to a line on the other side of the switch. This ensures that no current flows in winding *L* when the alternator is switched off from the circuit to which it is supplying power. A secondary winding *O* of the transformer is connected to a bridge rectifying circuit *P* which is, in turn, connected to the coil. Adjustment of the circuits and modified arrangements are also shown in the specification.—*December* 12, 1956.

Calendars and Diaries

We acknowledge receipt of calendars and/or diaries for 1957 from the undermentioned firms :—

RUSTON-BUCYRUS, Ltd., Lincoln.
BROOK MOTORS, Ltd., Huddersfield.
BUTTERS BROS. AND CO., Ltd., Glasgow.
HIGH DUTY ALLOYS, Ltd., Slough, Bucks.
SENTINEL (SHREWSBURY), Ltd., Shrewsbury.
B. THORNTON, Ltd., Turnbridge, Huddersfield.
MARCONI INSTRUMENTS, Ltd., St. Albans, Herts.
THE CONNELL GROUP, Coatbridge, Lanarkshire.
COVENTRY GAUGE AND TOOL COMPANY, Ltd., Coventry.
NORTH BRITISH LOCOMOTIVE COMPANY, Ltd., Glasgow.
TAYLOR WOODROW, Ltd., 10, Park Street, London, W.1.
THE D.P. BATTERY COMPANY, Ltd., Bakewell, Derbyshire.
THE BRUSH GROUP, Ltd., Duke Street, St. James's, London, S.W.1.
EDWARD WOOD AND CO., Ltd., 68, Victoria Street, London, S.W.1.
EDWARDS HIGH VACUUM, Ltd., Manor Royal, Crawley, Sussex.
C. A. PARSONS AND CO., Ltd., Heaton Works, Newcastle upon Tyne, 6.
THE PHOTOGRAPHIC SURVEY CORPORATION, Ltd., Montreal, Canada.
LINDEMANN MASCHINENFABRIK G.M.B.H., Dusseldorf, Germany.
LE TOURNEAU WESTINGHOUSE COMPANY, Peoria, Illinois, U.S.A.
DAVIDSON AND CO., Ltd., Sirocco Engineering Works, Belfast, N. Ireland.
THE CAPE ASBESTOS COMPANY, Ltd., 114–116, Park Street, London, W.1.
NETTLE ACCESSORIES, Ltd., Harper Road, Wythenshawe, Manchester, 22.
BEN THORNTON AND PARTNERS, Ltd., 39, Victoria Street, London, S.W.1.
FISCHER BEARINGS COMPANY, Ltd., Upper Villiers Street, Wolverhampton.
THE HUNTING GROUP OF COMPANIES, Norwich House, Dunraven Street, London, W.1.
STEWARTS AND LLOYDS, Ltd., Brook House, Upper Brook Street, London, W.1.
LAURENCE, SCOTT AND ELECTROMOTORS, Ltd., 431, Grand Buildings, Trafalgar Square, London, W.C.2.
THE TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY, Ltd., Mercury House, Theobalds Road, London, W.C.1.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF MINING ELECTRICAL AND MECHANICAL ENGINEERS

Tues., Jan. 8.—LONDON BRANCH : 21, Bloomsbury Street, London, W.C.1, " Dangers Caused by Mechanical Plant at Mines and Quarries," A. E. Crook, 5.45 p.m.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Jan. 4.—LIVERPOOL BRANCH : Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, 2, " The Diesel Engine," R. V. Hughes, 7.30 p.m.
Mon., Jan. 7.—LEEDS BRANCH : Great Northern Hotel, Leeds, Films, 7.30 p.m.——N.E. LONDON BRANCH : Angel Hotel, Ilford, " Electricity as Applied to the Aircraft Industry," C. G. Hayward, 7.30 p.m.——SHEFFIELD BRANCH : Royal Victoria Station Hotel, Sheffield, Film Show, 7.30 p.m.
Tues., Jan. 8.—OXFORD, READING AND DISTRICTS BRANCH : Palmer Hall, West Street, Reading, " Earth Leakage Equipment," J. A. Robbins, 7.15 p.m.——TYNESIDE BRANCH : Visit to Consett Steel Works, 7 p.m.——W. LONDON BRANCH : Windsor Castle Hotel, 134, King Street, Hammersmith, " Generation of Electricity by Nuclear Energy," J. R. M. Southwood and J. Thompson, 7.30 p.m.
Wed., Jan. 9.—BIRMINGHAM BRANCH : Exchange and Engineering Centre, Stephenson Place, Birmingham, 2, " Properties of Silicones and their Application in Electrical and Engineering Industries," J. J. Newlands and G. L. Towers, 7.30 p.m.——BRADFORD BRANCH : Midland Hotel, Bradford, " Earthing Systems," 8 p.m.——HALIFAX BRANCH : Crown Hotel, Horton Street, Halifax, " Further Thoughts on Television," H. B. Reeder, 7.30 p.m.
Thurs., Jan. 10.—PORTSMOUTH BRANCH : Royal Beach Hotel, Southsea, " Further Thoughts on Application of Pyrotenax Cables in Buildings," 8 p.m.——S.W. LONDON BRANCH : Prince of Wales Hotel, London, S.W.19, " Illumination," C. F. Oliver, 8.30 p.m.
Fri., Jan. 11.—STOKE AND CREWE BRANCH : Grand Hotel, Hanley, Stoke, " Electronics in Industry," E. Heys, 7.30 p.m.

BELFAST ASSOCIATION OF ENGINEERS

Wed., Jan. 9.—College of Technology, Belfast, " The Early History of Hydraulic Machinery," H. G. Conway, 7.30 p.m.

BRITISH INSTITUTE OF MANAGEMENT

Tues., Jan. 8.—Management House, 8, Hill Street, London, W.1, " New Fields for Quality Control," R. M. Belbin, 6.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Jan. 9.—LONDON SECTION : School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, Films, 6.30 p.m.——W. MIDLANDS SECTION : Technical College, Wulfruna Street, Wolverhampton, " Design and Application of Magnetic Amplifiers," R. G. Russell-Bates, 7.15 p.m.
Fri., Jan. 11.—SCOTTISH SECTION : Department of Natural Philosophy, The University, Edinburgh, " Potted Components and Assemblies," H. G. Manfield, 7 p.m.

BRITISH INTERPLANETARY SOCIETY

Sat., Jan. 5.—Caxton Hall, Caxton Street, London, S.W.1, " Astronomy and Earth Satellites," Michael W. Ovenden, 6 p.m.

COVENTRY ENGINEERING SOCIETY

Thurs., Jan. 10.—Coventry Victor Social Club, Coventry, Film Show, " Tulip Rally and Alpine Rally," 7.30 p.m.

ELECTRICAL POWER ENGINEERS' ASSOCIATION

Mon., Jan. 7.—LONDON TECHNICAL GROUP : Caxton Hall, Westminster, London, S.W.1, " Radioactive Techniques in Industry," J. L. Putman, 7 p.m.

ILLUMINATING ENGINEERING SOCIETY

Tues., Jan. 8.—SESSIONAL MEETING : Lighting Service Bureau, 2, Savoy Hill, London, W.C.2, " Lighting as an Effective Aid to Architecture," H. R. Ruff, H. E. Bellchambers and R. V. Mills, 6 p.m.
Wed., Jan. 9.—EDINBURGH CENTRE : Y.M.C.A., 14, South St. Andrew Street, Edinburgh, " The Electrical Contractors' Approach to Artificial Lighting," E. Cassidy, 6.15 p.m.——NEWCASTLE UPON TYNE CENTRE : Department of Electrical Engineering, King's College, College Road, Newcastle upon Tyne, 1, " The Lighting of Small Factories," J. S. McCulloch, 6.15 p.m.——SWANSEA GROUP : S. Wales Electricity Board, The Kingsway, Swansea, " Maintenance of Lighting Installations," J. W. Strange, 6.30 p.m.
Thurs., Jan. 10.—GLASGOW CENTRE : Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank Crescent, Glasgow, C.2, " How I Look at Lighting Engineering," C. Stuart and L. C. Rettig, 6.30 p.m.

INCORPORATED PLANT ENGINEERS

Tues., Jan. 8.—LONDON BRANCH : Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, " Acoustics and Vibration," W. A. Hines, 6.30 p.m.——EDINBURGH BRANCH : 25, Charlotte Square, Edinburgh, " Electronics in Industry," R. B. Smith, 7 p.m.——MANCHESTER BRANCH : Engineers' Club, Albert Square, Manchester, " Floor Loadings," S. C. Swan, 7.15 p.m.
Wed., Jan. 9.—E. MIDLANDS BRANCH : Sherwood Room, County Hall, Theatre Square, Nottingham, " The Severn Barrage Scheme," B. D. Richards, 7 p.m.——LEICESTER BRANCH : Bell Hotel, Leicester, " Incentive Schemes for Maintenance Work," D. J. Winfield, 7 p.m.——WESTERN BRANCH : Grand Hotel, Bristol, "Factory Electrical Distribution Systems," R. H. Cobbold, 7.15 p.m.
Thurs., Jan. 10.—GLASGOW BRANCH : Scottish Building Centre, 425–427, Sauchiehall Street, Glasgow, " Current Lubricants and their Significance to Plant Engineers," S. F. Chisholm, 7.15 p.m.——N.W. BRANCH : Roadway House, Oxford Street, Newcastle upon Tyne, " Space Heating," F. W. Watson, 7 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Mon., Jan. 7.—LANCASHIRE BRANCH : Midland Hotel, Manchester, " Co-operation and Co-ordination between Pattern Shop and Foundry," E. H. Beech and N. Bradshaw, 7 p.m.——SHEFFIELD BRANCH : College of Commerce and Technology, Department of Engineering, Pond Street, Sheffield, " Foundry Maintenance," G. L. Jenkins, 7 p.m.
Wed., Jan. 9.—SCOTTISH BRANCH : University College, Dundee, " Malleable Castings for the Engineering Industry," H. J. Conacher, 7.30 p.m.——BURNLEY SECTION : Accrington Further College of Education, Sandy Lane, Accrington, " Hot Blast Cupolas," J. Henderson, 7.30 p.m.
Thurs., Jan. 10.—LINCOLNSHIRE BRANCH : Technical College, Lincoln, Report of Sub-Committee T.S. 44 of the Technical Council, 7.15 p.m.——BEDS AND HERTS SECTION : W. H. Allen, Sons and Co., Ltd., Bedford, " Reduction of Dust in the Production of Loose Pattern Moulds by Core Assembly," E. H. Beech, 7.30 p.m.——STOKE SECTION : Stipendiary Court Room, Hanley, " American Ferrous and Non-Ferrous Foundry Practice," T. Johnson, 7.30 p.m.
Fri., Jan. 11.—TEES-SIDE BRANCH : Teesdale Hall, Head Wrightson and Co., Ltd., Thornaby-on-Tees, " The Practical Aspects of the Uses of CO_2 in the Foundry," G. B. Taylor, 7.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., Jan. 7.—MERSEYSIDE AND N.W. SECTION : Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, " Practical Application of the 1952 Fire Appliance Rules," G. Keenan, 6.30 p.m.

INSTITUTE OF METALS

Tues., Jan. 8.—OXFORD LOCAL SECTION : Cadena Cafe, Cornmarket Street, Oxford, " Gases in Metals," C. E. Ransley, 7 p.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Tues., Jan. 8.—6, Buckingham Gate, London, S.W.1, " The Economics of Machinery Investment on the Farm," F. G. Sturrock and J. R. Warburton, 5.30 p.m.
Mon., Jan. 14.—NORTHERN CENTRE : N.E. Electricity Board's Lecture Theatre, Carliol House, Newcastle, " Modern Crop Spraying Technique," F. W. Morris, 6.45 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., Jan. 8.—Geological Society, Burlington House, London, W.1, " Solution of the Equations for Mass-Transfer in Plate-Type Distillation Columns," H. H. Rosenbrock, 5.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Jan. 8.—ROAD MEETING : Great George Street, Westminster, London, S.W.1, " Organisation and Control of Highways Maintenance," W. J. Hiscock, 5.30 p.m.
Wed., Jan. 9.—A.L.G.S. MEETING : Great George Street, Westminster, London, S.W.1, " Inland Waterways," C. M. Marsh, 5.30 p.m.
Thurs., Jan. 10.—RAILWAY MEETING : Great George Street, Westminster, London, S.W.1, " The Application of Works Study to Railway Civil Engineering Maintenance," P. D. T. Pescod and J. C. F. Cameron, 5.30 p.m.——N.W. ASSOCIATION : Engineers' Club, Albert Square, Manchester, " The Analys's of Prestressed Concrete Structural Members and the Application of Recent Research," P. B. Morice, 6.30 p.m.
Sat., Jan. 12.—MIDLANDS ASSOCIATION : James Watt Memorial Institute, Great Charles Street, Birmingham, " Prestressed Concrete as Applied to Building Frames," Francis Walley and H. C. Adams, 6 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Jan. 7.—S. MIDLAND CENTRE : James Watt Memorial Institute, Great Charles Street, Birmingham, " Recruitment to the Engineering Profession," 6 p.m.
Tues., Jan. 8.—MEASUREMENT AND RADIO SECTION : Savoy Place, London, W.C.2, " A Theoretical and Experimental Investigation of Anisotropic-Dielectric-Loaded Linear Electron Accelerators," R. B. R.-Shersby-Harvie, L. B. Mullett, W. Walkinshaw, J. S. Bell and B. G. Loach, 5.30 p.m.
Wed., Jan. 9.—N. SCOTLAND SUB-CENTRE : Caledonian Hotel, Aberdeen, " Colour Television," G. N. Patchett, 7.30 p.m.
Thurs., Jan. 10.—ORDINARY MEETING : Savoy Place, London, W.C.2, " Some Aspects of Heat-Pump Operation in Great Britain, with particular reference to the Shinfield Installation," Miriam V. Griffith, 5.30 p.m.
Mon., Jan. 14.—INFORMAL MEETING : Savoy Place, London, W.C.2, Discussion on " The Influence of Maintenance Requirements on the Design of Industrial Electrical Equipment," opened by H. C. Fox and J. H. Harris, 5.30 p.m.

INSTITUTION OF ENGINEERS-IN-CHARGE

Wed., Jan. 9.—St. Bride Institute, Bride Lane, Fleet Street, London, E.C.4, " Automatic Level Control in Boilers," C. G. Scolding, 6 p.m.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS

Mon., Jan. 7.—N.E. COAST BRANCH : Institute of Mining and Mechanical Engineers, Neville Street, Newcastle upon Tyne, 1, " Some Notes on the Choice of Mechanical Stokers for Boiler Plants," E. J. C. Macdonald, 6.30 p.m.
Wed., Jan. 9.—Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, " Mechanical Services in the Central Area of London Airport," R. E. Tully, 6 p.m.
Thurs., Jan. 10.—BIRMINGHAM AND DISTRICT BRANCH : Exchange and Engineering Centre, Stephenson Place, Birmingham, " Modular Co-ordination," M. Hartland Thomas, 6.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Tues., Jan. 8.—AUTOMOBILE DIVISION GENERAL MEETING IN CONJUNCTION WITH THE HYDRAULICS GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, " A Review of Hydro-Kinetic Fluid Drives and their Possibilities for the British Motor Industry," J. G. Giles, 6 p.m.
Wed., Jan. 9.—E. MIDLANDS BRANCH : College of Technology and Commerce, Leicester, Annual Meeting, " A Standard Gas Turbine to Burn a Variety of Fuels," G. B. R. Feilden, J. D. Thorn and M. J. Kemper, 7.15 p.m.——YORKSHIRE GRADUATES' SECTION : Visit to Redfern Brothers, Ltd., Glassworks, Barnsley, 6.30 p.m.
Thurs., Jan. 10.—LUBRICATION GROUP DISCUSSION : 1, Birdcage Walk, Westminster, London, S.W.1, " Diagnosis of Causes of Plain Bearing Failure," 6.45 p.m.
Fri., Jan. 11.—GENERAL MEETING IN CONJUNCTION WITH THE INTERNAL COMBUSTION ENGINE GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, " An Analogue for High-Intensity Steady-Flow Combustion Phenomena," D. B. Spalding, 6 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Mon., Jan. 7.—ORDINARY MEETING : Institution of Electrical Engineers, Savoy Place, London, W.C.2, " Auto. Exch. Maintenance Procedure : Past, Present and Future," S. Sudeforth, K. S. Laver and E. R. Driver, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Tues., Jan. 8.—LONDON GRADUATE SECTION : 10, Chesterfield Street, London, W.1, " Broaches and Broaching," W. L. Soden, 7.15 p.m.
Wed., Jan. 9.—LIVERPOOL SECTION : Bradford Hotel, Tithebarn Street, Liverpool, " Cutting Tools : Application and Research," M. O. Short, 7.30 p.m.——PRESTON SECTION : College of Further Education, Sandy Lane, Accrington, " The Manufacture and Application of Ball and Roller Bearings," R. V. Jones, 7.15 p.m.——S. ESSEX SECTION : Mid-Essex Technical College, Chelmsford, " Electronic Computer Control of Machine Tools," 7.30 p.m.——WOLVERHAMPTON SECTION : Technical College, Wolverhampton, " Industrial Research," P. Spear, 7.15 p.m.
Thurs., Jan. 10.—LEICESTER SECTION : Grand Hotel, Leicester, Film and Lecture, " Material Handling for the Small Firm," 7 p.m.——ROCHESTER SECTION : Sun Hotel, High Street, Chatham, " Modern Gear Production," H. J. Watson, 7.30 p.m.
Fri., Jan. 11.—DERBY SECTION : College of Art, Green Lane, Derby, " Time and Motion Study in the Automobile Industry," A. J. Hornsby, 7 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., Jan. 7.—N.E. SECTION : Eldon Grill, Grey Street, Newcastle, Film Evening, 7 p.m.
Tues., Jan. 8.—LONDON SECTION : Royal Society of Tropical Medicine and Hygiene, 26, Portland Place, London, W.1, " Electronic Force Measurement in Rubber Testing," A. E. Eagles and A. R. Payne, 7 p.m. ; " Phenolic Resins as Reinforcing Agents," S. M. Ardley, 5.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Tues., Jan. 8.—LONDON GRADUATES' AND STUDENTS' SECTION 11, Upper Belgrave Street, London, S.W.1, Address by the President, J. Guthrie Brown, 6.30 p.m.——N. IRELAND BRANCH : College of Technology, Belfast, " Developments in Prestressing Equipment," 6.45 p.m.
Thurs., Jan. 10.—11, Upper Belgrave Street, London, S.W.1, " Static Stresses in Electric Overhead Travelling Crane Girders," E. Lightfoot and N. Jackson, 6 p.m.——LANCASHIRE AND CHESHIRE BRANCH : Engineers' Club, Albert Square, Manchester, " The Analysis of Prestressed Concrete Structural Members and the Application of Recent Research," P. B. Morice, 6.30 p.m.

INSTITUTION OF WATER ENGINEERS

Fri., Jan. 11.—S.E. SECTION : Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, " The Water Supply of Singapore," W. S. Stredwick, 2.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Jan. 4.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Film Evening, 7 p.m.
Fri., Jan. 11.—ORDINARY MEETING : Pepys House, 14, Rochester Row, Westminster, London, S.W.1, " Metal Bending," R. A. Johnson, 7 p.m.

LIVERPOOL ENGINEERING SOCIETY

Wed., Jan. 9.—24, Dale Street, Liverpool, " Mineral Insulated Metal-Sheathed Cables," J. A. McCleery, 6 p.m.

LIVERPOOL METALLURGICAL SOCIETY

Thurs., Jan. 10.—The University, Liverpool, Student Prize Competition, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

Fri., Jan. 11.—Engineers' Club, Albert Square, Manchester, " Arbitration and Awards," G. D. Walford, 6 45 p.m.

NEWCOMEN SOCIETY

Wed., Jan. 9.—Iron and Steel Institute, 4, Grosvenor Gardens, London, S.W.1, " The Crampton Locomotive : Part II," P. C. Dewhurst, 5.30 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Jan. 11.—Mining Institute, Newcastle upon Tyne, " Comprehensive Trials of Complete Marine Propulsion Turbine Installations," H. E. C. Hims, 6.15 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Jan. 8.—SECTION LECTURE : 4, Hamilton Place, London, W.1, " The Significance of Flow Separation in Three Dimensions," C. Maskell, 7 p.m.
Thurs., Jan. 10.—Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, Presidential Address, E. T. Jones, 6 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., Jan. 7.—ORDINARY GENERAL MEETING : 12, Great George Street, London, S.W.1, " The Heating of Buildings by Warm Air," W. Davidson, 5.45 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Wed., Jan. 9.—CORROSION GROUP : 14–16, Belgrave Square, London, S.W.1, " Corrosion Problems in Nuclear Power Production," A. B. McIntosh, 6.30 p.m.

SOUTH WALES INSTITUTE OF ENGINEERS

Thurs., Jan. 10.—Park Place, Cardiff, " Drifting at Pentrecwydau Colliery," E. J. H. Nicholas, 6 p.m.

Advanced Engineering Courses

Liquid Fuels : Their Properties and Utilization. By G. F. J. MURRAY. Borough Polytechnic, Borough Road, London, S.E.1. Course of eight lectures commencing January 17. Thursdays at 7 p.m. Fee £1.

Atmospheric Pollution : Its Causes, Effects and Prevention. Borough Polytechnic, Borough Road, London, S.E.1. Course of five lectures commencing January 22. Tuesdays at 7.30 p.m. Fee 10s.

Automation. Borough Polytechnic, Borough Road, London, S.E.1. Course of twelve lectures commencing January 16, Wednesdays at 7 p.m. Fee £1.